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ILLINOIS TURFGRASS FOUNDATION

WELCOMING ADDRESS
H.B. Petty

The University of Illinois College of Agriculture is pleased that you are here. We do hope you enjoy your visit with us. You are always welcome on this campus and, in the words of a song, not just today but always. Just as you are salesmen and have a product, we, too, are salesmen. We are called salesmen of knowledge. Some of us have visited you at your place of business; now you are at our place of business. In this context today you are our customers. We have facts and information to sell--facts and information which will help you make your decisions. When we do not have facts to answer your question we should know where to get them, or be able to give an answer based on experience and probabilities, or see your request as a research need. Our situation is unique at the University--we are a land-grant university. Congress designated such a university in every state to research the problems of agriculture and to help adopt the practices dictated by research. We are set up to serve students, agriculture, agri-business, and homeowners.

Let's look at the structure of this College of Agriculture as we are set up to serve the educational needs of the people of Illinois. We have a Dean who heads up our organization, and he is responsible to the Chancellor, the Board of Trustees, and an advisory committee of Illinois citizens. We have four arms--teaching, research, extension, and international agriculture. We have 14 technical departments specializing in specific subject matter. Within each department are staff members paid wholly or in part to do teaching, research, and/or extension. In 10 regions in Illinois we have regional directors and some area advisers who are commodity oriented and not departmentally oriented. The University of Illinois maintains--with the assistance of local people--a county staff consisting of an agricultural adviser, home economist, and youth adviser. Call on your county advisers for immediate help.

We are obligated to help educate young people. Our student enrollment in agriculture has grown at a more rapid rate than the total enrollment of the Universit Ornamental horticulture has been an important and integral part of this growth. We have had little trouble placing our graduates in agriculture, and our horticultural graduates have been placed with no difficulty.

Our Extension program is strong. We have active off-campus programs which have been popular and are steadily increasing in popularity--training schools, Tele-Net programs, radio, and TV programs. By working together we can supply homeowners with the best information.

These good, aggressive, and progressive programs involve the Departments of Horticulture, Entomology, Plant Pathology, Home Economics, Agricultural Economics, and many others--a true interdisciplinary approach. You have a resource here and throughout the state to use in your business.

To close, we are pleased you have confidence in us and attend the Turf Grass Conference, but call upon us all year. We think we have a saleable product--education. The facts and information are here. We hope you will use us.

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CONTENTS

RESEARCH SESSION

FACTORS AFFECTING NITROGEN AVAILABILITY FROM IBDU

T.D.Hughes

Turfgrass managers and industry and university personnel have a major task at hand; namely, that of improving the environment. The environment must be improved both esthetically and biochemically. This points to the necessity of utilizing fertilizer materials in ways which not only promote turfgrass growth, but also do not cause undesirable pollution problems. The recent problem of energy supplies also points to the importance of efficient use of fertilizer supplies. This cannot be accomplished without a thorough understanding of chemical properties of fertilizer materials and their release characteristics.

Several controlled-release nitrogen fertilizer materials are available, and new materials are being developed and introduced into the market. Many commercial lawn and turfgrass fertilizer materials contain ureaformaldehyde (UF). This material, as well as milorganite, has been marketed for a number of years, and both release nitrogen as a result of microbial activity in soil. Sulfur-coated urea (SCU) is not being produced commercially in large quantities, but has been used experimentally for several years. SCU is currently receiving considerable attention as a relatively inexpensive controlled-release nitrogen source for many crops. At present, several different SCU materials exist which release nitrogen at different rates. A resin-coated material (Osmocote) is available in a variety of analyses which also include phosphorus and potassium. A new material, organiform, is now being produced and marketed. This material is made by combining UF with leather tankage protein or sewage sludge. This material is similar to UF and milorganite with respect to nitrogen release in that microbial activity is required. This list is by no means complete for the U.S. market. Other materials are currently being produced abroad which may appear on the U.S. market in the future.

In past sessions at this conference, it was reported that laboratory research on factors affecting release of nitrogen from IBDU were underway. The following is a list of conclusions that have been reached thus far.

1. Considerable ammonium may accumulate in soils at about two weeks following application. This is especially true in soils having pH less than 6.0 and if small fertilizer particles (i.e., 0.6 to 0.7 mm) are applied. If soil temperatures are in the vicinity of 70° F., the ammonium will disappear and nitrate will be the predominant form resulting from fertilizer application within three to four weeks.

2. The effects of soil pH are relatively minor except during about the first six weeks following application.

3. Particle size is much more important than soil pH in affecting nitrogen release. In soils ranging in pH from 5.7 to 7.4, about 75 percent of nitrogen is released

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from 0.6 to 0.7 mm particles in 10 weeks. In contrast to this, only 50 percent of the nitrogen applied as 1.6 to 2.0 mm particles is released in 32 weeks. This data was obtained in soil at 70° F. and with moisture content at field capacity.

4. Soil moisture content can be expected to have pronounced effects. This parameter is currently under investigation.

5. Previous reports of urea accumulations in soil were incorrect. Urea appears in extracts as a result of hydrolysis of IBDU during the extraction procedure.

YELLOW NUTSEDGE CONTROL IN KENTUCKY BLUEGRASS TURF

A.J. Turgeon and D.W. Black

Yellow nutsedge is a serious weed of lawns and intensively cultured turfs which has increased in occurrence and distribution in recent years. Studies were undertaken to determine the effects of cultural practices and Kentucky bluegrass competition on the growth and development of yellow nutsedge.

In a greenhouse study six yellow nutsedge plants were planted in glass-sided boxes with and without Kentucky bluegrass, and additional boxes were planted with Kentucky bluegrass alone. Half of the boxes were mowed weekly, while the other half were unmowed for the first 12 weeks, then mowed weekly for the remainder of the 32-week experimental period. Observations were made on shoot density, below-ground development, and tuber formation. Nutsedge density was highest in boxes in which nutsedge was planted alone and not mowed. Mowing or competition with Kentucky bluegrass substantially reduced nutsedge density during the initial 12 weeks of the experiment; however, the combination of mowing and competition with Kentucky bluegrass held the nutsedge population virtually in check. This same effect was observed eventually in the previously unmowed boxes in which mowing was initiated after the twelfth week; by the twenty-eighth week, nutsedge density in these boxes was at six or less plants per box. Visual observation of the below-ground development of nutsedge revealed considerable rhizome formation in boxes in which nutsedge was planted alone and not mowed, while very little rhizome development was evident where mowing and/or competition with Kentucky bluegrass were factors. Tuber development was zero in mowed boxes and substantial in the unmowed boxes; however, competition with Kentucky bluegrass sharply reduced the amount of tubers produced.

In a field study, yellow nutsedge was planted in plots of Kentucky bluegrass turf and maintained at 3/4, 1 1/2, and 3 inches cutting height, and fertilized at 0, 1/2, 1, or 2 lb. N/1,000 sq. ft. per month from May to October. The highest nutsedge density occurred in plots maintained at 3/4 inch, suggesting that the nutsedge is well adapted to a close-mowing regime. Initially, fertilization appeared to enhance nutsedge growth, but this trend was reversed by the end of four months. This was probably due to the response of Kentucky bluegrass to fertilization during late summer. Thus, the success of nutsedge as a weed in turf is apparently associated with conditions that reduce the competition from Kentucky bluegrass.

Bentazon, cyperquat, and MAMA were applied to control yellow nutsedge on a golf course tee of Kentucky bluegrass maintained at 3/4 inch cutting height. The herbicides were applied at various rates; repeat applications and the addition of surfactant to the spray solution were also included in the test. Control estimates were made approximately three and seven weeks after initial treatment. Plugs were extracted from each plot and nutsedge tubers were separated and counted. Nutsedge control was best in plots receiving two applications of any of the three herbicides under evaluation. Where effective control of the nutsedge shoots was observed, tuber development was also substantially reduced. Some temporary discoloration was observed in the MAMA-treated plots, while no injury was evident from the

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bentazon or cyperquat treatments. There was substantial variability among replications that was associated with differences in irrigation coverage; generally better control was observed in the more intensively irrigated plots. Based on this observation and subsequent greenhouse tests, it was concluded that frequent irrigation for a period of several weeks prior to herbicide treatment enhances control of yellow nutsedge with herbicides.

EFFECTS OF SUBSURFACE AND CORE CULTIVATION ON SOIL STRENGTH IN A WASHINGTON CREEPING BENTGRASS TURF

A.J. Turgeon and J.C. Siemens

The traditional means of alleviating soil compaction under an established turf has been through core cultivation. This is a form of cultivation involving the use of hollow tines or spoons to extract soil cores from a turf. The cores are then either removed, or pulverized in place and the soil is dragged back into the turf. Results of such an operation include: greater water infiltration, deeper turfgrass rooting and increased shoot density, disruption of undesirable layers in the soil horizon, enhanced decomposition of thatch, and improved resiliency of the turfgrass surface. Core cultivation may also facilitate the escape of toxic gases in the turfgrass rootzone. Visual observation of soil profiles from previously cultivated turf usually reveals masses of roots growing in the holes or cavities that resulted from coring; however, little new rooting is observed in other sections of soil underlying these turfs. Thus, the benefits from core cultivation are very localized, and repeated cultivations would be necessary to bring about a generalized improvement in rooting.

A new concept in turfgrass cultivation was introduced with the development of the Jacobsen Sod Master Sub Air. This machine was designed to penetrate the soil to a depth of five or seven inches and to lift and shatter the compacted soil mass. Since little experience has been accumulated with this method of cultivation, an experiment was initiated in August, 1973, to compare the effects of core versus subsurface cultivations, with and without topdressing, on a Washington creeping bentgrass turf. Treatments were performed as listed in Tables 1 and 2. Plots measured 6 by 10 feet, and each treatment combination was replicated six times. The soil was moderately moist at the time of treatment. Soil strength measurements were made using an ASAE soil cone penetrometer inserted between the holes or lines, two and twelve months after treatment. Results indicated that no significant reduction of soil compaction was obtained from subsurface cultivation, and only a slight reduction of soil compaction was apparent in the surface one to two inches from core cultivation two months after treatment (Tables 1 and 2). The data also show that the soil depth at which maximum resistance to penetration occurred was at approximately three inches, regardless of treatment. This corresponded to the maximum penetration depth of the tines during core cultivation. Since this turf had been core cultivated at least yearly for a period of eight years or more prior to the initiation of this experiment, it was concluded that repeated core cultivations may have induced development of the compacted zone at the three-inch soil depth. If so, subsurface cultivation may be important in reducing an undesirable effect of core cultivation by slicing through the subsurface compaction zone. Although further work will be necessary to substantiate this conclusion, insertion of the penetrometer into the lines from subsurface cultivation two months after treatment revealed that the subsurface compaction zone had been cleaved.

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The continuous lines of penetration resulting from subsurface cultivation were evident in the turf through the fall and winter following treatment, especially where topdressing soil had not been applied. Apparently, topdressing is an important practice for reducing turfgrass injury from desiccation along the lines of penetration. This was in sharp contrast to the core-cultivated plots in which the holes disappeared by approximately one month following treatment. Very little desiccation was observed in the turf adjacent to the small holes.

A further conclusion from this work was that subsurface cultivation would be more effective as soil moisture decreases. At high soil moistures, the machine may simply compress the soil on either side of the lines of penetration. Thus, the desired conditions underwhich optimum results would be expected from subsurface cultivation are quite different from conditions favoring core cultivation; the soil must be fairly moist to allow maximum penetration of the tines or spoons from the core cultivor.

Subsurface and core cultivation may actually be complementary procedures rather than alternative methods for dealing with the same problem. Under dry soil conditions, subsurface cultivation may effectively reduce subsurface soil compaction, but cause substantial tearing and disruption of the turf. This operation should be performed when climatic conditions favor rapid turfgrass recovery. Core cultivation is a less destructive procedure which may be performed several times during the growing season to reduce surface compaction and promote new shoot and root growth.

Table 1. Effects of Cultivation and Topdressing on Soil Strength in a 'Washington' Creeping Bentgrass Turf Treated August 16, 1973, and Measured With a Core Penetrometer on October 11, 1973[a]

		Depth, inches[d]							
Cultivation[b]	Topdressing[c]	0	T	1	2	3	4	5	6
Subsurface	+	11.1	14.5	12.0	15.9	20.2	19.6	16.6	14.5
Subsurface	-	10.8	15.0	11.2	14.4	18.7	17.2	15.5	12.9
Coring	+	10.1	13.7	10.3	12.9	19.8	18.7	15.2	12.2
Coring	-	9.5	12.2	10.0	13.7	19.4	17.1	14.2	12.8
None	+	10.7	14.2	11.0	14.4	19.3	18.3	16.0	13.7
None	-	10.2	13.8	10.8	13.6	17.9	16.2	13.8	11.7
LSD .05		.7	1.1	.9	1.4	2.2	3.3	2.8	2.3

[a]Table values are the means of three replications per plot, and three plots per treatment. Measurements were made with an ASAE soil core penetrometer.
[b]Cultivation methods included: subsurface cultivation using a Jacobsen's Sod Master Sub-Air with 5-inch knives; and core cultivation using a Ryan Greens Air with 0.5-inch hollow tines.
[c]Topdressing was performed with a 1:1 mixture of coarse sand and silty clay loam soil applied at the rate of 0.25 cubic yards per 1,000 square feet.
[d]Depth measurements were made at 1- or 2-inch increments plus the point at which the core penetrated the thatch (T).

Table 2. Effects of Cultivation and Topdressing on Soil Strength in a 'Washington' Creeping Bentgrass Turf Treated August 16, 1973, and Measured on August 21, 1974[a]

Cultivation[b]	Topdressing[c]	Depth, inches[d]							
		0	T	1	2	3	4	5	6
Subsurface	+	8.2	13.5	11.1	12.6	15.9	14.4	11.3	9.9
Subsurface	-	8.3	13.3	10.2	12.1	15.5	13.0	10.7	9.4
Coring	+	7.8	11.2	8.8	10.3	15.1	14.3	11.7	9.8
Coring	-	8.0	12.1	9.1	12.1	15.8	13.7	10.5	8.7
None	+	8.1	13.6	10.8	13.0	16.2	13.8	11.4	9.9
None	-	9.2	13.5	10.2	12.1	15.3	13.4	9.9	9.1
LSD .05		1.1	1.4	1.9	1.5	2.1	3.4	2.5	2.4

[a]Table values are the means of three replications per plot, and three plots per treatment. Measurements were made with an ASAE soil core penetrometer.

[b]Cultivation methods included: subsurface cultivation using a Jacobsen's Sod Master Sub-Air with 5-inch knives; and core cultivation using a Ryan Greens Air with 0.5-inch hollow tines.

[c]Topdressing was performed with a 1:1 mixture of coarse sand and silty clay loam soil applied at the rate of 0.25 cubic yards per 1,000 square feet.

[d]Depth measurements were made at 1- or 2-inch increments plus the point at which the core penetrated the thatch (T).

INDIRECT EFFECTS OF PESTICIDES ON SOIL PHYSICAL AND CHEMICAL PROPERTIES

I.J. Jansen

Turgeon, Freeborg, and Bruce found that calcium arsenate and bandane herbicides increased wilt tendency and induced thatch development in turf. They also observed that earthworms were absent in plots treated with calcium arsenate or bandane, though plentiful in plots that received other treatments.

These particular herbicides apparently are toxic to earthworms. Earthworms are known to digest large amounts of dead plant material and move it down into the soil. Thatch developed in those plots where earthworms were absent, but was prevented from forming in those plots where earthworms were abundant.

Since it is also known that earthworm activity improves soil structure, we should expect to find differences in the physical properties of the soil in addition to the difference in thatch development between those plots where earthworms are abundant and those plots where earthworms are absent. The wilt tendency that was observed after treatment with calcium arsenate or bandane could be caused by changes in the physical properties of the soil as well as by the development of thatch.

We are now beginning a study to determine just how the soil is changed by the use of certain herbicides. Preliminary data indicate that soils in plots that have been treated with calcium arsenate: have a lower infiltration rate; store less water at low tension levels; and have a higher bulk density than soils in plots that have not received a herbicide treatment.

Each of the changes in soil properties mentioned would have some practical significance for turfgrass management. A lower infiltration rate means that water enters the soil more slowly. This causes more of the water which falls on the surface to run off and less to soak into the soil where it would be available to the growing plants. Because the treated soils apparently also have a lower capacity to store water, more frequent watering would be needed even if enough water were applied each time to completely wet the soil. Soils with a high bulk density are usually more resistant to root penetration than soils with a low bulk density. The poorer rootings observed under the thatchy turf could be caused in part by the higher bulk density of the soil.

Further study is needed to confirm these preliminary observations. A better understanding of the indirect effects of turf management practices will enable us to improve our ability to solve turf management problems.

REFERENCE

Turgeon, A.J., R.P. Freeborg, and W.N. Bruce. Thatch Development and Other Effects of Preemergence Herbicides in Kentucky Bluegrass Turf. Agronomy Journal (in press). 1975.

I.J. Jansen is Assistant Professor of Pedology, Department of Agronomy, University of Illinois.

ANNUAL GRASS CONTROL IN TURF

A.J.Turgeon

Annual grass weeds of turf include crabgrass (*Digitaria* spp.), goosegrass (*Eleusine indica* (L.) Gaertn.), yellow foxtail (*Setaria glauca* (L.) Beauv.), and some biotypes of annual bluegrass (*Poa annua* L.). Most of these germinate and emerge in established turf from mid-spring to mid-summer, except annual bluegrass which can develop at almost anytime during the season when conditions are favorable. The primary means of controlling annual weeds is through the establishment of a vigorous, dense turf composed of specied and varieties that are well adapted to existing environmental conditions. However, turf is not always maintained under optimum conditions; improperly performed cultural practices, heavy traffic, and other factors may result in the deterioration of a turf that, in turn, is more susceptible to the invasion of annual weeds.

The introduction of preemergence herbicides approximately 15 years ago was one of the most dramatic developments in the history of turfgrass technology. Well-established cultural principles could be ignored, or at least compromised, through the timely provision of a "chemical blanket" from preemergence herbicide application to preclude annual grass development from germinating seeds. In the early 1960's, annual preemergence herbicide use in early to mid-spring became a routine practice on many turfs. In some cases, two or more applications were made during the season to "strengthen" the chemical blanket, and for added control of annual bluegrass. Subsequently, reports of turfgrass injury from repeated use of preemergence herbicides on Kentucky bluegrass (5,6) and bentgrass (1,3,4) were published. This injury was manifested as increased disease incidence, higher wilting tendency, thatch development, and/or general deterioration of the turf. Also, Gaskin (2) reported an inhibition of rhizome growth from some herbicides. Thus, an interesting paradox emerged with the use of preemergence herbicides in some instances--herbicides used to prevent weed development in a poor turf were themselves causing further deterioration of the turf. This is not to imply that preemergence herbicides should not be used. They are important tools for the turfgrass manager in achieving desirable turfgrass quality where annual weed pressure is a concern. However, preemergence herbicides alone will not guarantee satisfactory turf in the absence of a sensible cultural program.

The current inventory of commercially available preemergence herbicides does not yet include the "perfect" herbicide. Complete prevention of all annual weeds throughout the entire growing season with virtually no adverse effects on turfgrasses is not possible at this time; but acceptable weed control with tolerable turfgrass injury usually is. However, improved herbicides should be sought through a continuous program of evaluation of candidate materials.

The 1974 preemergence herbicide evaluation at the Ornamental Horticulture Research Center in Urbana included 56 treatments. Herbicides were applied in April to established Kentucky bluegrass that had been vertically mowed and overseeded with

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crabgrass. Plots measured 5 x 6 feet, and each treatment was replicated three times. The plots were monitored for crabgrass germination and turfgrass injury, and control data were taken in late August. Additional studies were performed at Belleville with several preemergence herbicides to determine turfgrass injury from applications to 'Penncross' creeping bentgrass, maintained as putting green turf, and Kentucky bluegrass that was partially submerged by water at the time of treatment.

Results from the crabgrass control test showed good to excellent control with Betasan, Dacthal, Balan, Emblem, PPG-139, Ronstar, and Tolban (Table 1). Devrinol and EL-131 also provided good crabgrass control at adequate application rates, but turfgrass injury was moderate to severe indicating a rather narrow margin of safety. Modown, Vel-4207, and Vel-5052 were ineffective in controlling crabgrass at the applied rates. The compounds CGA-17020 and CGA-24705 were highly injurious to the turf, resulting in negative crabgrass control.

No significant increase in crabgrass control was obtained from watering in the Emblem, Balan, and Alachlor treatments. Repeated treatments of Emblem improved control over the single applications. Two applications of the Dacthal WP or F formulations at 5.3 pounds per acre were as effective in controlling crabgrass as single applications at 10.5 pounds per acre or higher. Phytotoxicity to 'Penncross' creeping bentgrass turf was substantial following treatment with EL-131, moderate with Ronstar and calcium arsenate, and very slight with Betasan (Table 2). When preemergence herbicides were applied to partially submerged Kentucky bluegrass, Dacthal treatment resulted in severe injury to the turf, while phytotoxicity was moderate from EL-131, Emblem, and Ronstar (Table 3). The surprising effect of Dacthal may be of practical concern in situations where aerial application is contemplated due to partially submerged conditions in spring.

Table 1. Crabgrass Control and Turfgrass Injury From Preemergence Herbicides Applied in April, 1974[a]

Treatment	Form[b]	Rate, lb./A.	Crabgrass % cover	Crabgrass % control	Phytotoxicity[c]
Alachlor	4E	3	13.3	50	1.0
		3[d]	17.7	34	1.0
		6	7.0	74	1.0
		6[d]	8.7	67	1.0
Balan.	2.5G	2.5	2.7	90	1.0
		2.5[d]	1.7	94	1.0
Betasan.	4E	7.5	.3	99	1.0
		10	0	100	1.0
	3.6G	7.5	0	100	1.0
		10	1.7	94	1.0
	12.5G	7.5	1.0	96	1.0
CGA-17020.	5G	1	43.3	-62	1.0
		2	41.7	-56	1.0
	4E	2	25.0	6	1.0
CGA-24705.	5G	1	48.3	-81	3.0
			45.0	-69	2.0
	6E		19.3	28	1.0

Table 1 (cont.)

Treatment	Form[b]	Rate lb./A.	Crabgrass % cover	Crabgrass % control	Phytotoxicity[c]
Dacthal.	75WP	10.5	0	100	1.0
		15	1.0	96	1.0
	6F	10.5	0	100	1.0
		15	.3	99	1.0
	75WP	10.5+5.3[e]	.3	99	1.0
		5.3+5.3[e]	.7	97	1.0
	6F	10.5+5.3[e]	0	100	1.0
		5.3+5.3[e]	.3	99	1.0
Devrinol	2E	2	8.7	67	3.0
		4		100	6.0
EL-131	50WP	1.5	1.7	94	2.0
		3	2.0	93	6.7
		6	0	100	8.0
Emblem	25WP	2.5	11.7	56	2.0
		2.5[d]	6.7	75	1.0
		2.5+2[e]	.3	99	2.0
		2.5+2[d,e]	1.7	94	1.0
Modown	80WP	2	18.3	31	1.0
		4	11.7	56	1.0
PPG-139.	5G	10	.3	99	1.0
		15	1.0	96	1.0
		20	.7	97	1.0
PPG-139.	3F	10	6.0	78	1.0
		15	.7	97	1.0
		20	0	100	2.0
Ronstar.	2G	2	2.7	90	1.0
		3	1.0	96	2.0
		4	0	100	3.0
Tolban	2G	1	6.0	78	1.0
		2	3.7	86	1.0
		3	2.7	90	1.0
Vel-4207	2E	1	26.7	0	1.0
		2	25.0	6	1.0
		4	13.3	50	2.0
Vel-5052	2E	.25	21.7	5	1.0
		.5	30.0	-12	1.0
		1.0	18.3	31	1.0
Untreated.			26.7		1.0

[a]Table values are the means of three replications.
[b]E = emulsifiable concentrate, G = granular, WP = wettable powder, and F = flowable.
[c]Phytotoxicity based on a scale of 1 to 9 with 1 representing no injury and 9 representing complete necrosis of the turf.
[d]These treatments were not watered in after application.
[e]The second application was made on June 10. All initial applications were made April 26, 1974.

Table 2. Turfgrass Injury From Preemergence Herbicides Applied to 'Penncross' Creeping Bentgrass in April, 1974[a]

Treatment	Form	Rate, lb./A.	Phytotoxicity
Betasan	4E	10	1.7
	12.5G	10	1.3
Ronstar	2G	3	2.7
EL-131	50WP	3	4.7
Calcium arsenate	70WP	186	2.7
Untreated			1.0

[a]Table values are the means of three replications; phytotoxicity based on a scale of 1 to 9 with 1 representing no injury and 9 representing complete necrosis of the turf.

Table 3. Turfgrass Injury From Preemergence Herbicides Applied to Kentucky Bluegrass Partially Submerged Under Water in April, 1974[a]

Treatment	Form	Rate, lb./A.	Phytotoxicity
Alachlor	4E	3	2.0
Balan	2.5G	1.5	1.7
		3	1.3
Betasan	12.5G	10	1.7
Dacthal	6F	12	4.7
	75WP	12	5.3
EL-131	50WP	1.5	2.3
		3	3.3
Emblem	25WP	1.5	2.3
		3	3.0
Ronstar	2G	3	2.7
Tupersan	50WP	12	1.7
Untreated			1.0

[a]Table values are the means of three replications; phytotoxicity based on a scale of 1 to 9 with 1 representing no injury and 9 representing complete necrosis of the turf.

REFERENCES

1. Callahan, L.M. Phytotoxicity of Herbicides to a Penncross Bentgrass Green. *Weed Science* 20:387-391. 1972.
2. Gaskin, T.A. Effect of Preemergence Crabgrass Herbicides on Rhizome Development in Kentucky Bluegrass. *Agronomy J.* 56:340-342. 1964.
3. Juska, F.V., A.A. Hanson, and A.W. Hovin. Phytotoxicity of Preemergence Herbicides. *USGA Green Section Record* 8:2-5. 1970.
4. Roberts, E.C. and D.R. Brockshus. Kind and Extent of Injury to Greens From Preemergence Herbicides. *The Golf Superintendent* 34:13,16,18,36. 1966.
5. Turgeon, A.J. Herbicides and Their Effects on the Turfgrass Ecosystem. *Illinois Research* 15(2):17. 1973.
6. Turgeon, A.J. Effects of Successive Applications of Preemergence Herbicides on Turf. *Weed Science* 22:349-352. 1974.

TURFGRASS RESPONSE TO AQUATIC HERBICIDES IN IRRIGATION WATER

R. C. Hiltibran and A. J. Turgeon

Aquatic weeds can present serious problems in irrigation ponds by clogging irrigation lines and pumps, interfering with play on golf courses, and detracting from the aesthetic value of the landscape. Attempts at controlling aquatic weeds with herbicides are limited by the subsequent use of the water for irrigating putting greens and other turfs. This experiment was designed to evaluate the suitability of various aquatic herbicides in terms of their safety to intensively cultured turf.

The herbicides were added to barrels of water at normal treatment concentrations and the water was then applied to Penncross creeping bentgrass, maintained as putting green turf, at 9.8 gallons per 30 square feet of plot (equivalent to one-half inch of irrigation). Applications were made twice in the Spring study (May 31 and June 3), four times each in the Spring-Summer (May 31, June 3, and July 29 and 30) and Summer-Summer (July 30 and 31, August 7 and 8) studies, and twelve times in the multiple Summer study (from August 14 to September 17).

Turfgrass injury varied with type and formulation of herbicide, and timing, rate, and number of applications (Table 1). No injury was observed in plots treated with any of the copper compounds, diuron, fenac, 2,4-D amine, or endothall formulations. Diquat and 2,4-D ester were slightly to moderately injurious depending upon rate and number of applications. Silvex, dichlobenil, and simazine were moderately to highly injurious and resulted in complete loss of turf in some instances.

An additional consideration when using herbicide-treated water for irrigating turf is the residual toxicity of the herbicide in water. The relatively short residual activity of diquat in the aquatic environment would allow for safe use of diquat-treated water soon after treatment. In contrast, 2,4-D ester, silvex, and dichlobenil have a longer residual life in the water and require a longer waiting period between treatment and use of the water for irrigating bentgrass turf.

R.C. Hiltibran is Biochemist, Illinois Natural History Survey, and A.J. Turgeon is Assistant Professor, Department of Horticulture, University of Illinois.

Table 1. Potential Hazard to Creeping Bentgrass Turf From Aquatic Herbicides in Irrigation Water

Aquatic herbicide	Rate, ppm[a]	Hazard[b]
Copper sulfate.	1 (Cu)	low
Copper-triethanolamine complex[c]	1 (Cu)	low
Diuron.	0.25	low
Endothall		
potassium salt.	1	low
N,N-dimethylalylamine salt[d]	1	low
mono (dimethyltridecylamine oxide).	1	low
di (dimethyltridecylamine oxide).	1	low
Fenac	2	low
2,4-D		
dimethylamine salt.	2	low
butoxyethanol ester	2	moderate
butoxyethanol ester	4	moderate
Diquat.	1	moderate
Diquat + copper-triethenolamine	1+1 (Cu)	moderate
Dichlobenil	2	high
	1	moderate
Silvex		
butoxyethanol ester	2	high
potassium salt + endothall[e]	2+1	moderate
Simazine.	0.5	high

[a]Rates expressed as acid equivalent or active ingredient of each herbicide rather than as salt or ester formulation.

[b]Hazards expressed as: low (little likelihood of turfgrass injury from use), moderate (some thinning and discoloration of turf), and high (severe injury or loss of turf).

[c]Cutrine Plus.

[d]Hydrathol-47.

[e]Aquathal Plus.

RESEARCH ON NEW PERENNIAL RYEGRASS VARIETIES

C. Reed Funk

Perennial ryegrass (*Lolium perenne* L.) is an important cool-season grass widely used for both forage and sports turf in areas with maritime climates such as New Zealand, Holland, and the British Isles. Nearly all currently available varieties originated from germplasm obtained from these areas during the past few decades. Such varieties perform best in these maritime climates where summers are cool and moist and winters are relatively mild. Such ryegrass are not as winter-hardy as Kentucky bluegrasses, bentgrasses, or the fine-leaved fescues. With the increasing use of ryegrass in regions having a continental climate, efforts are being made to develop varieties with tolerance for extremes of hot summers and cold winters. Since perennial ryegrass occurs naturally throughout wide areas of temperate Asia and North Africa, it should be possible to find germplasm with improved tolerance to heat and cold. Recent visitors to the USSR report ryegrass growing in native pastures in areas having very cold winters.

Prior to about 1960, nearly all ryegrass breeding programs throughout the world concentrated on the improvement of perennial ryegrass for hay and pasture purposes. Improved strains which were developed in Europe and New Zealand represented two rather distinct classes: (a) the late-flowering, persistent pasture varieties which produce abundant tillers, many leaves, and relatively few stems; and (b) the early-flowering, more erect pasture/hay varieties which are not as leafy or persistent as the pasture types. These pasture/hay types are more leafy and persistent than the common types of perennial ryegrass such as Oregon Common and Linn.

The leafy, persistent pasture-type varieties were found to have considerable merit for sports turf when compared with common perennial ryegrass, and a number of varieties have been widely used for this purpose.

TURF-TYPE RYEGRASS VARIETIES

The improved performance of the leafy, persistent ryegrasses for sports turf encouraged breeders to direct their efforts to developing ryegrass varieties specifically adapted for turf use without regard to their value in forage production. This has led to the development of finer textured, leafy, persistent, turf-type varieties of improved mowability and attractiveness which are also somewhat lower growing than varieties originally bred for forage production. This improved group of turf-type ryegrasses includes the varieties Manhattan, Pennfine, NK200, Eton, Birdie, Citation, Yorktown, Derby, and Diplomat. These new turf-type varieties are substantially superior to common perennial ryegrass for many turf purposes in their area of adaptation. Like all ryegrasses, the new turf-types are quickly and easily established and are adapted to a wide range of soils and uses. When properly managed, in their area of adaptation, the improved turf-type ryegrasses can be durable, persistent, and attractive. The professional turf grower should become knowledgeable on the strengths and weaknesses of the turf-type ryegrasses,

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their areas of usefulness, where they should and should not be used, and their management requirements.

WINTER PERFORMANCE

A number of the turf-type ryegrasses, including Eton, NK200, Manhattan, and Yorktown, appear to be substantially more winter hardy under most circumstances than common perennial ryegrass. Nevertheless, additional improvements in winterhardiness are needed for many of our more severe climates. Improved resistance to some winter diseases, including the snow molds and a winter brown blight disease, is also an objective of ryegrass breeding programs. The winter brown blight disease caused by *Helminthosporium siccans* has been observed on ryegrass trials during mild, wet winters in New Jersey and is reported to be a problem on ryegrass sports turf in Europe. Ryegrass varieties have shown considerable variation in resistance to this disease in field trials at Rutgers.

Table 1. Reaction of Perennial Ryegrass Varieties to the Winter Brown Blight Disease in New Jersey

Variety	Percent disease	
	Dec. 1972	Jan. 1974
Yorktown	9	5
Pelo	9	6
Manhattan	15	7
Diplomat	23	8
NK200	18	16
NK100	30	18
Linn	35	20
Eton	--	23
Derby	--	24
Pennfine	66	29
Citation	74	29
LSD at 5 percent	11	9

SUMMER PERFORMANCE

The turf-type ryegrass varieties Citation, Pennfine, Birdie, Derby, and Diplomat have shown significant improvements in heat tolerance and summer performance compared with most other ryegrasses under New Jersey conditions. The Rhizoctonia brown patch disease, favored by warm, humid weather and high nitrogen fertilization, can frequently cause serious damage to ryegrass. All European-developed varieties tested in New Jersey have shown a rather high degree of susceptibility to this destructive disease. Some of the new turf-type varieties originating from germplasm collected from old turf stands of the mid-Atlantic area have shown moderately good resistance to Rhizoctonia brown patch. Such varieties include Citation, Pennfine, and Diplomat (Table 2). A breeding program to develop increased levels of resistance to this disease is in progress at Rutgers.

MOWING CHARACTERISTICS

The turf-type ryegrass varieties Citation, Eton, NK200, Pennfine, Birdie, Diplomat, Yorktown, Manhattan, and Derby all show substantial improvements in ease of mowing when compared with common perennial ryegrass. When growing conditions are favorable, these varieties can be mowed cleanly with little difficulty. Under

Table 2. Reaction of Perennial Ryegrass Varieties to the Rhizoctonia Brown Patch Disease at New Brunswick, New Jersey in June, 1973

Variety	Damage from brown patch, 9 = most diseased
Citation	3.0
Pennfine	3.3
Diplomat	3.3
Yorktown	5.0
NK200	5.0
Manhattan	6.2
Splendor	6.3
Game	6.3
Pelo	6.7
NK100	7.0
Caprice	8.0
Linn	8.4
LSD at 5 percent	1.4

certain stress conditions all ryegrasses can be difficult to mow. Further improvements in mowing quality is a prime objective of all turf-oriented ryegrass improvement programs. None of the above varieties is a marked improvement over other turf-type ryegrasses in mowing quality at all seasons of this year. Eton and NK200 frequently rank best in mowability during the cool weather of spring and fall, but cannot be mowed as well as many of the others during heat stress periods of June through September. A number of European varieties such as Sprinter also show an above average reduction in mowing quality with increasing heat stress. The early flowering varieties, including Pennfine, Citation, Derby, and Birdie, normally produce an abundance of stemmy reproductive tillers during May, and become much more difficult to mow when compared with Diplomat, Manhattan, NK200, and Eton. Citation, Pennfine, Diplomat, and Birdie normally have the highest ratings for mowability during July, August, and September (Table 3).

Frequent cutting with a sharp, well-adjusted mower is important in the maintenance of attractive ryegrass turf. Ryegrass varieties are frequently slow to recover from the effects of excessive clipping removal.

TURF DENSITY AND TEXTURE

The turf-type ryegrasses can produce a very attractive turf during the cool weather of spring and fall if properly managed. Tiller density counts and leaf width measurements obtained at New Brunswick, New Jersey, during November showed that the better turf-type ryegrasses produced turf of greater density and finer leaves than an adjacent plot of high-quality Merion Kentucky bluegrass. This test received adequate fertility for good performance and was mowed frequently (two or three times weekly) at 1-inch with a sharp reel mower (Table 4).

COLOR

The color of common perennial ryegrass is frequently too light to blend well with most varieties of Kentucky bluegrass and fine fescue. Most of the new turf-type ryegrasses have a bright, moderately dark-green color. Citation and Yorktown generally have shown the darkest green color in New Jersey tests (Table 5).

Table 3. Mowing Quality Ratings of Perennial Ryegrass Varieties at Adelphia, New Jersey (9 = Best)

Variety	Early spring and fall	Late spring	Summer	Cool versus hot
Eton	7.1		5.0	-2.1
NK200	7.0		5.0	-2.0
Citation	7.0	Stemmy	6.8	- .2
Diplomat	6.8		6.6	- .2
Yorktown	6.5		5.9	- .6
Manhattan	6.5		5.8	- .7
Pennfine	6.3	Stemmy	6.1	- .2
Derby	6.2	Stemmy	6.0	- .2
Sprinter	6.2		4.8	-1.4
Pelo	5.0		3.8	-1.2
NK100	4.8	Stemmy	3.4	-1.4
Game	3.6	Stemmy	2.8	- .8
Linn	3.4	Stemmy	2.4	-1.0

Table 4. Tiller Density and Leaf Width Measurements of Perennial Ryegrass Varieties Maintained at High Fertility and Frequent, Close Mowing at New Brunswick, New Jersey, November, 1973

Variety	Tillers per 100 sq. cm.	Leaf width, mm.
Diplomat	352	1.6
Pennfine	322	1.8
Citation	321	2.0
Yorktown	308	1.8
Manhattan	288	1.9
Pelo	251	2.2
NK100	220	2.3
Game	207	2.3
Linn	206	2.3
LSD at 5 percent	34	.2
Merion	226	2.4

Table 5. Color Ratings of Perennial Ryegrass Varieties at New Brunswick, New Jersey

Variety	Color rating 9 = darkest
Citation	8.0
Yorktown	7.5
Manhattan	6.7
Diplomat	6.5
Pennfine	6.2
NK200	5.8
Game	4.8
NK100	4.5
Pelo	4.2
Linn	3.8
LSD at 5 percent	.7

SHADE TOLERANCE

The turf-type ryegrasses appear to perform better in light to moderate shade compared with common perennial ryegrass. Turf-type ryegrasses growing in cool shade also appear to have less of a mowing problem. While the turf-type ryegrasses will not persist well in heavy shade, they can frequently be useful in such areas for a somewhat temporary turf. The rapid establishment of these ryegrasses can enable them to produce several months of turf cover during periods when the tree leaves are absent. This turf will then persist for a number of weeks into the summer after the tree leaves return.

ESTABLISHMENT

The rapid, easy establishment of the turf-type ryegrasses has been a prime factor in their popularity with both homeowners and turf professionals. Some germination can be observed within five days under favorable temperature and moisture conditions. A rather nice turf cover ready to mow can be produced within three weeks if fertility, moisture, and temperature conditions are near optimum and disease is not a problem. Unfortunately seedling diseases can be a serious problem during certain seasons of the year. Pythium damping-off can be serious under hot, humid, wet conditions. Seed treatment with Koban has been effective in helping control this disease in overseeding trials in the South. Rhizoctonia brown patch can also damage seedling turf in warm, humid periods. These seedling diseases are most severe where nitrogen fertility and seeding rates are excessively high.

OTHER FACTORS

All ryegrasses show varying degrees of susceptibility to the crown rust disease *(Puccinia coronata)* with Birdie and Pennfine showing the most resistance in New Jersey tests. Rust is seldom a serious problem on ryegrass turf if growing conditions are favorable and fertility levels are adequate to promote good growth. Leaves are removed by clipping before the disease (which can only grow on living tissue) has a chance to develop. When growth slows down in late summer or fall because of heat and drouth stress or low fertility, the rust may develop and discolor the turf.

The Corticum red thread disease can damage ryegrass during periods of cool, cloudy weather, especially when fertility levels are inadequate.

A blend of adapted bluegrasses should normally be mixed with the turf-type ryegrasses to improve long-term performance. Where soil and management conditions favor the bluegrasses and where adapted, highly competitive bluegrasses are used the ryegrass will frequently be crowded out and replaced by the bluegrass turf.

NEW FINELEAF FESCUES — POTENTIAL FOR TURF

Kenyon T. Payne

Kentucky bluegrass has been referred to as the "queen of the cool-season grasses;" beautiful, adaptable, hardy, and currently prolific--with many exciting new progenies appearing.

The fine fescues may be considered the "prince" at this point in time, with many good qualities--handsome, rugged in drouth and shade tolerance, able to perform well on a lean diet, and a good companion for other cool-season grasses. Except for a severe disease problem, *Helminthosporium*, which causes leaf spot and, when severe, melting out, the red fescues could become king, as the discovery of Merion elevated the bluegrasses from the role of princess to that of queen in the 1940's.

Festuca is a large genus, containing over 100 species. These species include a broad range of plant types, from the narrowleaf, 42-chromosome red fescues to the wideleaf meadow and tall fescues. There are creeping rhizomatous types and bunch or chewings types, and they range in color from the silver-blue-green sheep fescues to the very dark-green red fescues. They have superb summer dormancy ability, low water-use rate, and the lowest level of nutrient requirements of any of our cool-season turfgrasses. These are increasingly important characters as we enter the era of conservation of energy and water supplies.

In addition, the red fescues have a good level of shade adaptation, and develop extremely attractive lawns when disease is not a problem. Where they can be grown, they provide the best possible fairway for the golfer, with short, stiff leaves to support the ball for a sweeping wood shot, but with the firm soil surface beneath which allows for the ideal iron shot.

Unfortunately, there is not available today one red fescue variety that is resistant to leaf spot. This is not for lack of trying. The USDA Yearbook of Agriculture for 1937 listed several states doing breeding in the 1920's and 1930's. As yet, however, no turfgrass breeder has been successful, nor has a Joe Valentine-type golf course superintendent (you will remember that it was he who discovered Merion) come up with a red fescue that stayed green during the brown out of a leaf spot infestation.

Having conducted a breeding program to solve this problem for several years, it is now understood why resistant varieties have not appeared--leaf spot resistance is a very elusive character. Since 1968 Dr. Joe Vargas and I have screened tens of thousands of individual plants through five generations at Michigan State University. We have not yet found one resistant mother plant which produces a high proportion of resistant progenies, and we have only isolated 27 resistant plants. In our screening technique we inoculate surviving plants four times, and increase the spore load each generation so we are applying severe disease stress.

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We now have these 27 plants cloned to six plants each, and intercrossed seed will be produced in the summer of 1975. The seed from these crosses will provide the first plants thus far available for testing in which both the male and female parents are leaf-spot resistant. The results will give us a good lead as to whether we are being successful in concentrating enough genes for resistance to produce a good cultivar.

Leaf spot in the red fescues occurs during the warm months in most of the cool, humid regions. In the more northerly latitudes where cooler summer temperatures prevail, it is a lesser problem. In the more southern latitudes of the central United States the extended periods of higher temperatures in the summer result in more severe attacks of the disease which may result in so-called "melting out" and death of the plant. The stress of dense shade also weakens the fescue plant, and diseases then thin stands and usually eliminate them.

For the above reasons, it is difficult to become enthusiastic about any of the currently available cultivars of red fescue. General appearance ratings taken throughout the growing season, and over several years, provide us with data which allow for the selection of a few varieties which will be superior to others in density and dark-green color during periods when leaf spot is not present.

In tests at M.S.U., Dawson has topped the list in this regard, although it suffered an attack of dollar spot in 1974 and was the only cultivar infected.

Oregon K has been second in performance, and is being considered for increase and release by the Oregon Agricultural Experiment Station.

Jamestown has had much more limited testing, but appears to have excellent color, texture, and density.

C-26, known in Europe as Bjilart, a hard fescue, has the greatest tolerance to leaf spot of the available cultivars, but critical tests have resulted in little true resistance and in poor appearance during disease periods.

Menuet has proven outstanding in northern Michigan trials, but has only average performance at East Lansing.

Red fescues have been a good companion for Kentucky bluegrass where soils and shade conditions are variable on a given site. They establish rapidly and yet do not compete as do the ryegrasses. Where soil spots are drouthy or shade thins the bluegrasses, the fescues often will survive. Until leafspot resistant cultivars are available, it is suggested that cultivars from the Good or Medium columns in the table below be selected for mixtures with Kentucky bluegrass.

Hopefully, some day we may be able to proclaim "The Prince is dead, long live the King."

Overall Performance Ratings of 28 Fine Fescues, Michigan State University, 1969 - 1974

Good	Medium	Fair	Poor
Dawson	Golfrood	Pennlawn	Illahee
Oregon K	Jamestown	Cascade	Boreal
C-26 Hand	Wintergreen	Oasis	Ranier
Menuet[a]	Highlight	Raptans	Steinacher
	Barfalla	Ruby	Olds
	Arctared	Bargena	Rapid
	S-59	Rubin	Cottage
	Polar		Echo
			Duraturf

[a]Excellent in northern Michigan.

NEW DEVELOPMENTS IN TURFGRASS EDUCATIONAL AIDS

R.L. Courson

The College of Agriculture at the University of Illinois has a "materials center" called VAS--Vocational Agriculture Service. It produces and distributes teaching aids and information on most phases of agriculture for schools, colleges, and other educational programs. Of special interest to such educators may be some new and up-to-date teaching aids and information on turfgrasses and ornamental horticulture. Most of this material is distributed within Illinois, but last year about 40 percent went to other states. It is priced only to recover the cost of production. The VAS catalog lists nearly 500 aids--from slide sets and tape recordings to subject-matter pamphlets and overhead transparencies.

The "lesson-size" subject-matter pamphlets make up the basic student text material in Illinois high school agricultural classes. They are also used in community colleges and other institutions. Each subject-matter unit is checked by one of the College specialists before being released.

Eighteen of the 169 subject-matter units available cover ornamental horticulture. The others are about equally divided among plant and soil science, animal and dairy science, agricultural economics, and agricultural mechanics. A new and growing category is also developing in agricultural business.

These units are priced by the page, and range from 4 to 44 pages each. For example:

VAS 5008--Establishing a Lawn, 8 p.	$.15
VAS 5015--Turfgrass Diseases and Their Control, 28 p.	$.45
VAS 5016--Identifying and Controlling Lawn Insects, 16 p.	$.25

Over 150 filmstrips are also available in these areas (35 mm single frame, for standard filmstrip projectors or for cutting and mounting as slides). Some of our new ones are available as 2- by 2-inch slide sets--65 in all. Most filmstrips have the text included on the frame and most slide sets have a syllabus or study guide booklet that accompanies each set. Cassette tapes are also made by the subject-matter specialist and can be used with the slide sets or filmstrips. This material is quite suitable for in-service training of employees or for service club presentations or talks. This material is available for sale rather than on a loan basis. For example:

	Slides	Filmstrip
650 Lawn Weeds--Identification and Control (39 fr.)	$ 6.45	$3.85
651 Steps to a Better Lawn (69 fr.)	11.30	5.15
652 Identifying Illinois Turfgrasses (64 fr.)	10.25	4.95

The overhead projector is a very popular method of presentation today. It allows "face to face" contact with your audience and also allows you to point out or add specific points as you talk. Many transparencies, however, used by some

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speakers do not contain art work or very large type. We have more than 1,000 prepared overhead transparencies available. The transparencies are already printed on plastic for direct use on an overhead projector. Also included is a white paper copy of each transparency with some text on the back for teacher use. The set is contained in a manila pocket folder for filing. Transparencies cost about 10 cents each. For example:

How Herbicides Work, Set of 46	$4.70
Weed Control, Set of 45	$4.60
Landscape Construction, Set of 86	$8.70
Landscape Planting and Bed Preparation, Set of 30	$3.10

New materials are constantly being developed. For teaching aids, write to Vocational Agriculture Service, University of Illinois at Urbana-Champaign, 434 Mumford Hall, Urbana, Illinois 61801.

Because of tax support from this state, Illinois orders are billed at a 20-percent discount under the prices listed. Orders are accepted without payment in advance, and shipping charges are added to those orders when billed.

If payment is sent with an order, please include the following additional amounts for postage and handling:

For orders under $10	add $ .50
For orders from $10 to $20	add $ .75
For orders over $20	add $1.00

Checks should be made payable to the University of Illinois.

GOLF TURF SESSION

PHYSICAL CONSIDERATIONS IN AMENDING PUTTING GREEN SOILS

L. Art Spomer

INTRODUCTION

Water is quantitatively probably the most important nutrient required for plant growth and survival. Actively growing grass tissue consists of about 90 percent water by weight. Plants not only contain large quantities of water, they also usually require hundreds of times this amount during growth. This enormous amount of water contained and used by plants is more than just an inert filler. Probably every plant growth activity is directly or indirectly affected by water. All of this water is absorbed from the soil through the plant's root system. Since water is very essential for plant growth and since all of the water used by plants comes from the soil, any factor affecting the absorption of water will therefore probably affect plant growth.

A number of biological, chemical, and physical factors directly and indirectly affect plant water absorption. These factors affect either soil water retention and movement or plant root growth and absorption. The primary soil physical factors affecting plant water absorption are *soil water content* and *soil aeration*. Water content is important because it indicates how much water is *potentially available* for plant use. Soil aeration (the exchange of oxygen and carbon dioxide between the soil and above-ground atmospheres) is important in maintaining a constant supply of the oxygen required for good root growth and absorption. Both aeration and water retention depend primarily on *soil structure* or the kind and arrangement of particles in the soil.

Most golf greens have two important features which distinguish them from other golf course turf areas: (1) They are subject to severe foot and mower traffic and (2) they are drained. The effects of the traffic are obvious (soil compaction, poor root growth and absorption); however, the effects of the shallow drainage (excess soil water content and poor soil aeration) are less obvious but are generalized in Figure 1. A *perched water table* forms at the drainage level in such a green following irrigation and drainage (1). Under these circumstances, any good, medium-textured natural soil will likely be saturated throughout (Fig. 1-B) and grass growth will probably be poor. Both problems are minimized in practice by amending the soil with coarse-textured materials (e.g. bark, calcined clay, gravel, perlite, sand, scoria, vermiculite, etc.) to increase the soil's resistance to compaction and to increase the amount of large or *aeration pores* which drain in spite of the water table (2). Unfortunately, too little amendment reduces both soil aeration and soil water retention without increasing the soil's resistance to compaction and too much reduces water retention excessively. The "optimum amount" of soil amendment should maximize soil compaction resistance and at the same time provide soil aeration and soil water retention which closely match those required for good turfgrass growth and water absorption.

L. Art Spomer is Assistant Professor, Department of Horticulture, University of Illinois, Urbana.

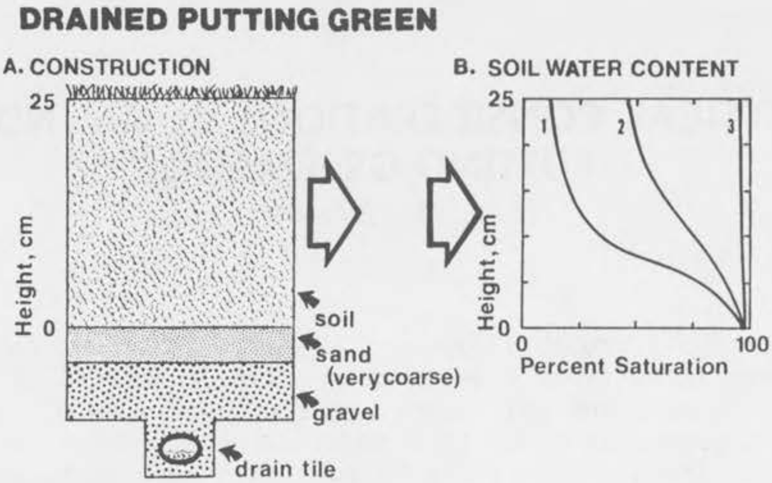


Figure 1. Water distribution pattern (B) for 3 different soils in a typical drained putting green (A). Soil 1 = coarse-textured sand; 2 = fine-textured sand; 3 = silty clay loam. All 3 soils are saturated at the drainage level (perched water table) and water content decreases with height above this level.

This article briefly discusses the changes in soil physical properties when natural soils are amended with coarse-textured materials.

SOIL AMENDMENT: SOIL PHYSICAL CHANGES

Figure 2 illustrates that soil and sand bulk volumes consist of both solids and pores. Figure 3 "pictures" what happens as a coarse-textured amendment is mixed with soil in increasing proportions. Since soil mixtures are usually prepared from bulk quantities (e.g. bu, ft^3, lit, m^3, yd^3, etc.), component and mixture quantities are herein expressed as bulk volumes. Bulk volume equals the total volume (solid + pore volumes). Beginning with 100 percent soil (10 yd^3), mixture porosity first decreases then increases with the addition of sand in increasing proportions. Porosity initially decreases because the sand "floats" in the soil or excludes soil and soil porosity without adding any large pores. The minimum porosity occurs at the *threshold proportion* which is the mixture in which the "mixing bin" is exactly full of sand and the large pores between the sand particles are exactly full of soil. In other words, the threshold proportion is determined primarily from the amendment's interporosity (Table 1). This is called the threshold proportion because it delimits the minimum proportion of sand amendment required before further amendment begins to improve soil aeration. Since at the threshold proportion the amendment particles first exhibit particle-particle contact, this also delimits the amount of amendment required to improve the soil's resistance to compaction. As the proportion of sand is increased beyond the threshold, the large pores between the sand particles (amendment interporosity) become voided of soil and both total and aeration porosity increase. This picture (Figure 3) suggests a simple mathematical model which can be used to predict mixture total and aeration porosities (Table 1) (2). This theoretical model is compared with actual total and aeration porosities of selected sand-soil mixtures in Figure 4. This data demonstrates that the theory accurately predicts mixture physical properties.

A simple graphical method for predicting soil total and aeration porosities from component individual porosities and bulk volumes is illustrated and explained in

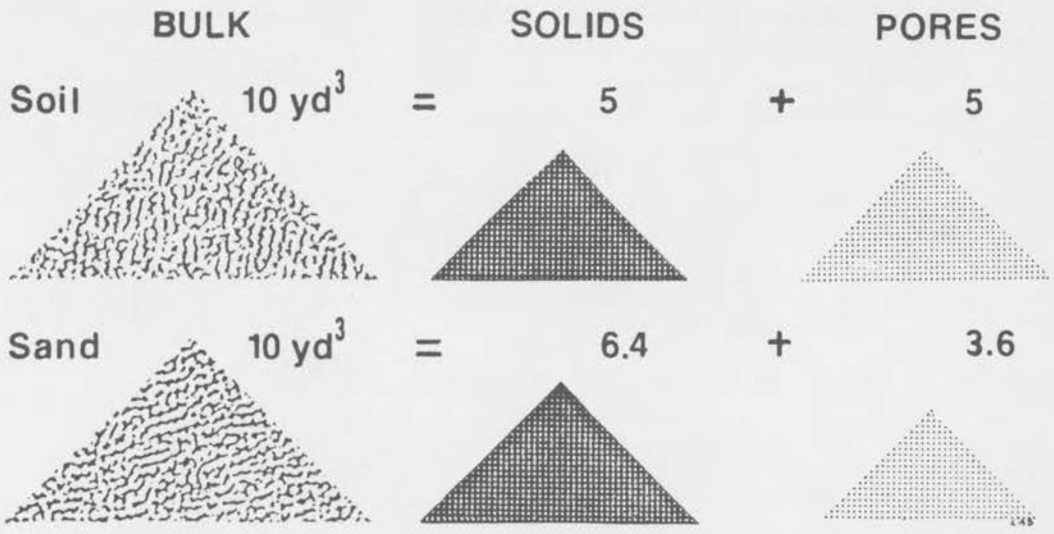


Figure 2. Solid and pore volumes of the soil and sand used in this study.

AMOUNT (bulk volume) OF SAND & SOIL, yd^3 in 10 yd^3 mixture

soil ▷	10.0	7.7	5.5	3.6	2.5	1.5	0.0
sand ▷	0.0	3.5	7.0	10.0	10.0	10.0	10.0
pores ▷	5.0	3.9	2.8	1.8	2.4	2.9	3.6

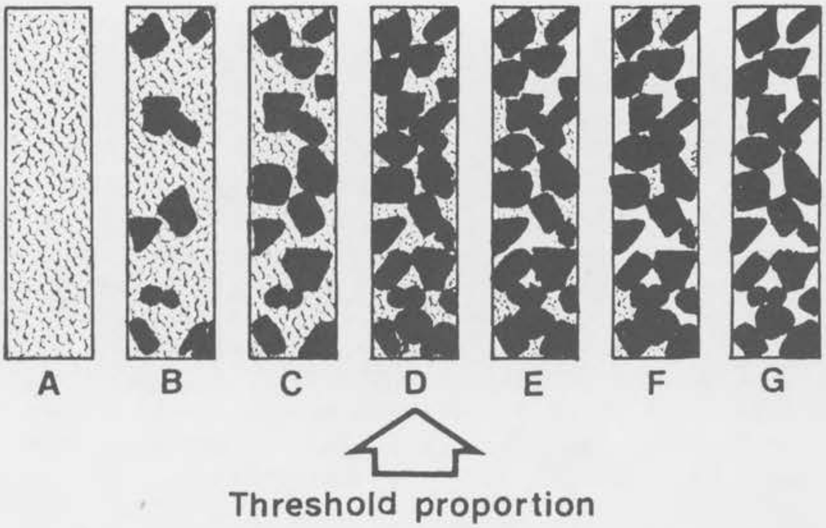


Figure 3. Microscopic "picture" of what happens to soil porosity as a coarse-textured amendment such as sand is added to the soil in increasing proportions.

Figure 5. The effect of pore size on soil-water distribution in a drained putting green is illustrated in Figure 1-B. In general, soils with smaller pores (soil) retain more water in the upper levels than those with larger pores (sand). The effect of different amounts of soil amendment on soil-water distribution in a drained green is illustrated in Figure 6. The addition of amendment (sand) up to the threshold proportion has no effect on the water distribution pattern, it merely

Table 1. Mathematical prediction of soil mixture total and aeration porosities.

$_aV_b$ less than threshold proportion:

$$E_m = [_mV_b - {_aV_b} (1-E_a)] [E_s] + {_aV_b}[E_a^*]$$

$$E_A = 0$$

$_aV_b$ greater than threshold proportion:

$$E_m = {_mV_b} - [_sV_b (1-E_s) + {_aV_b}(1-E_a)] + {_aV_b}[E_a^*]$$

$$E_A = E_m - [_sV_b (E_s) + {_aV_b} (E_a^*)]$$

E_A = Aeration porosity

E_a = Amendment interporosity (between particles)

E_a^* = Amendment intraporosity (within particles) (porous amendments)

E_m = Mixture porosity

E_s = Soil porosity

$_aV_b$ = Amendment bulk volume

$_mV_b$ = Mixture bulk volume

$_sV_b$ = Soil bulk volume

decreases the total porosity; however, when more amendment than the threshold is added, the water distribution pattern changes to that typical of the sand indicating that large pores have been formed and that aeration should increase. As amendment particle size decreases, the soil-water distribution pattern shifts toward the upper soil levels. When selecting an amendment, it is usually best to use one which has a relatively narrow range of particle sizes. Well-graded amendments with large amounts of fine-textured particles should be avoided because they are generally less efficient (larger amounts are usually required to produce soil physical improvement). Particle shape also affects amendment efficiency, but is much less important than size and size distribution.

CONCLUSION

This article does not recommend any specific putting green soil mixture but briefly describes what happens when an amendment such as sand is added to a soil. The "take-home" lesson is that a certain minimum proportion of amendment, the threshold proportion, is required before soil physical improvement is effected, and this amount is usually quite high (75 to 90 percent of the total bulk volume of the components). The optimum soil mixture depends on soil, amendment, climate, drainage depth, and plant species and is therefore difficult to determine without professional assistance.

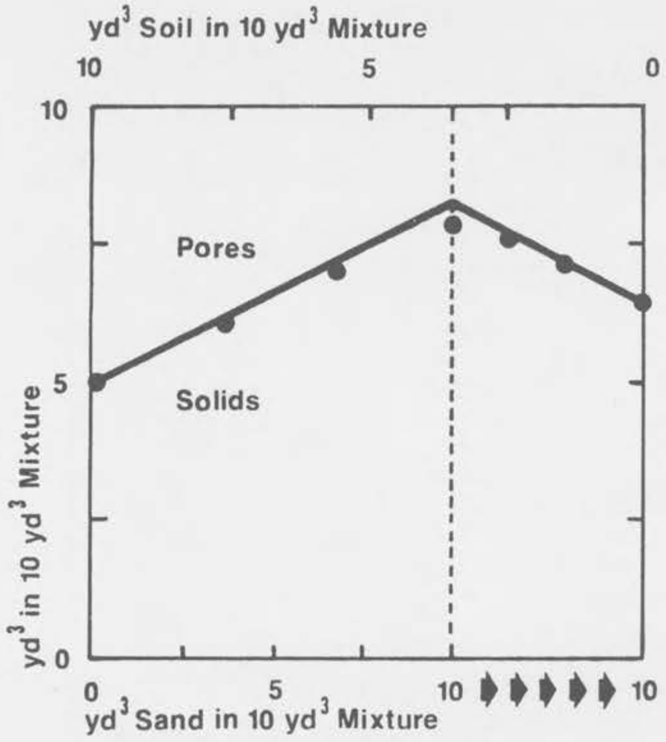


Figure 4. Theoretical (Table 1) and actual porosity in soil mixtures containing different amounts of sand.

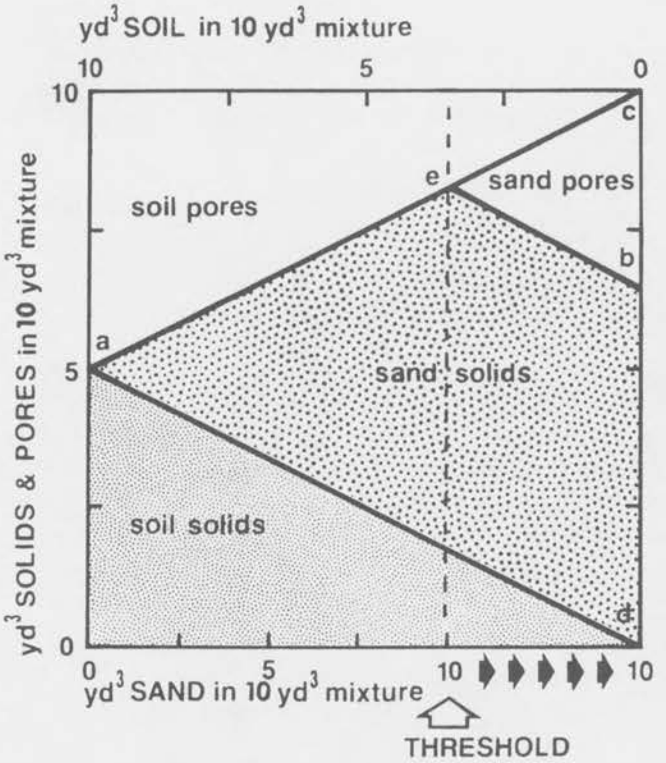
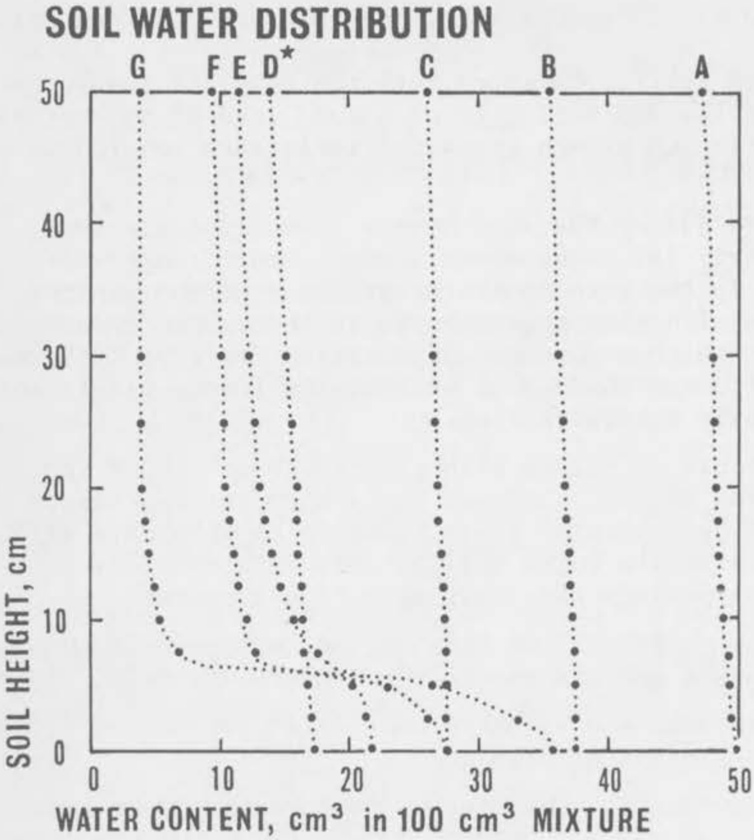


Figure 5. Graphical estimation of amended soil porosity from measurement of soil (a) and amendment (b) individual porosities and bulk volumes. Biagonals a-c and a-d delineate the soil's contribution to mixture pore and solid volumes, and line b-e (parallel to a-d) delineates amendment pore and solid volumes. Soil pore volume = water retention porosity and amendment pore volume = aeration porosity (in the mixture). For example, a mixture consisting of 10 yd^3 of this sand plus 2.5 yd^3 of soil results in 10 yd^3 mixture with 2.3 yd^3 total porosity of which 1.2 yd^3 is water retention and 1.1 yd^3 is aeration porosity.



BULK VOLUME, cm³ in 100 cm³ MIX

soil	sand	pores	mix
100	0	50	A
77	35	39	B
55	0	28	C
36	100	18	D*
25	100	24	E
15	100	29	F
0	100	36	G

****THRESHOLD***

Figure 6. Water distribution patterns of different sand-soil mixtures in a drained putting green.

REFERENCES

1. Spomer, L.A. Two Classroom Exercises Demonstrating the Pattern of Container Soil-Water Retention. HortScience 9(2):152-153. 1974.

2. Spomer, L.A. Optimizing Container Soil Amendment: The "Threshold Proportion" and Prediction of Porosity. HortScience 9(6): (In press). 1974.

BENTGRASS DISEASES AND THEIR CONTROL

W.A.Meyer

The most commonly grown varieties of creeping bentgrass in the midwestern United States are the seeded varieties Penncross and Seaside and the vegetatively propagated varieties Washington (C-50), Toronto (C-15), Cohansey (C-7), and Pennpar.

Dollar spot, caused by *Sclerotinia homeoecarpa*, and brown patch, caused by *Rhozoctonia solani*, are two of the most commonly occurring diseases on the above varieties in the midwest. Certain varieties such as Penncross and Pennpar appear to be more resistant to these diseases than the other varieties. Cohansey, on the other hand, is very susceptible to dollar spot, but has some tolerance to brown patch (2). Fortunately, we do have many fungicides available which effectively control these diseases.

Diseases caused by *Pythium* species are generally found on most of the commonly used varieties of bentgrass when environmental conditions are conducive to the development of *Pythium* species. Snow molds can also be serious on most of the varieties of bentgrass grown in the midwest during the winter months. Again, it is fortunate that effective fungicides are available which can control snow molds and *Pythium* blight.

Stripe smut, caused by *Ustilago striiformis*, is another disease which can attack most of the creeping bentgrass varieties grown in the midwest. Penncross is also susceptible, but it appears that this variety can tolerate the disease quite well in the summer time (3). Several studies have shown that benomyl can effectively control stripe smut in creeping bentgrass (3).

In the past few years, diseases caused by *Helminthosporium* species have been observed to be very serious on certain bentgrass varieties in Illinois. The two species most commonly found to attack creeping bentgrass varieties are *Helminthosporium sorokinianum* and *H. erythrospilum*. Both of these fungi are capable of causing both leaf spotting and crown and root rotting. *Helminthosporium sorokinianum* can attack most of the creeping bentgrass varieties, with the varieties Washington, Congressional (C-19), and Toronto being most susceptible and the varieties Penncross, Pennpar, and Cohansey showing some resistance (1).

In the Chicago area in the past three years, the variety Toronto has been found to be the most susceptible variety to *H. erythrospilum*, commonly referred to as red leaf spot. This same fungus is reported to be a serious pathogen in the east on most of the creeping bentgrass varieties except for Cohansey and Penncross (1). In one location in the Chicago area last year, the variety Cohansey was observed to have much better resistance to this disease than Toronto. The variety Washington was also observed to be seriously affected by *H. erythrospilum* in some Chicago-area test plots this past summer.

On Toronto the initial symptoms of this disease consist of small spots approximately ½ to 1 inch in diameter with indistinct margins. Plants in these spots have infected leaf tips that appear orange to reddish brown in color or leaves

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that were completely withered and bleached with a drouth-stricken appearance. The fungus can be easily isolated from leaves, crowns, and roots.

It was originally thought that heavy populations of nematodes may be a contributing factor in a disease complex. Nematicide applications made on diseased areas this past summer were shown to have no effect on the control of this disease.

Dr. Cole working in Pennsylvania has found that applications of Dyrene, Daconil, Tersan LSR, and the Actidione fungicides are effective in the control of this disease if applications are started in the early spring and continued on a preventive basis during the growing season (1).

In tests conducted on a severely diseased Toronto nursery located on the southwest side of Chicago, it was found that Daconil applied on a weekly schedule starting in April provided very good control of this disease. A rotation of Daconil and Dyrene also proved to be an effective control for this disease along with the Actidione fungicides which were more effective than Tersan LSR and a Tersan 1991 and LSR combination.

It was also found that a moderately good fertilizer program and early spring fertilization helped speed up the recovery process. Heavy applications of nitrogen, 2 pounds nitrogen to one thousand square feet, were found to make this disease more severe during the warm summer months. In July another trial was started on a severely diseased area adjacent to the plots which were treated beginning in April. Daconil was the only fungicide which helped improve the turf and this was only an inadequate 10 percent improvement.

These studies illustrate the need to spray fungicides on a preventive schedule to control *Helminthosporium* diseases of creeping bentgrass. Once the fungus infects the crown and root areas of the plants during the warmer periods of the late spring and summer, fungicide applications are of little value. It is also significant that the fungicide Daconil was the most effective control for *H. erythrospilum* in our studies, while Dyrene is reported to be the most effective control in the eastern United States (1).

REFERENCES

1. Cole, H. Personal Communication. 1974.

2. Hanson, A.A., F.V. Juska, and G.W. Burton. Species and Varieties. Pages 370-409 in Turfgrass Science, American Society of Agronomy, No. 14. 1969.

3. Hodges, C.F. Intensely Managed Turf: Prey to Stripe Smut. Pages 38-41 in Golf Superintendent, April. 1974.

AMENDING WATER WITH SOIL WETTING AGENTS

Robert A. Moore

The relationship of soil and water has been the subject of numerous studies. The vast majority of this work has been concerned with the soil phase. Synthetic organic compounds can be used in the soil to change or amend the water phase as well. This paper will review the work that has been done with these organic compounds. The data presented will be discussed on the basis of their effect on turfgrass growth, use, and management.

To help one grasp the significance of amending water, and comprehend the basic nature of this approach, one must consider the relationship: soil-water-air-plants. Most researchers have studied the effect of amending and managing soils on the development of plant varieties. Until recently, little or no work has been done on the amending of water. Water quality, availability, and movement in soils have been studied, but not the effect of physically changing water. The work of the past 10 to 15 years studying the influence of amending water presents a new and basic practice. The organic materials used for this purpose are called surfactants; short for surface-active agents. They include emulsifiers, detergents, dispersing agents, spreaders, sticking agents, and wetting agents.

Brandt (6) states that "surface-active agents have been studied for numerous agricultural purposes. Water repellent soils have been treated with wetting agents to improve water infiltration and percolation (8). Soil drainage has been accelerated (14), soil structure modified (16), foliar nutrient adsorption improved (5), evaporation retarded (26, 30), clays dispersed (47), and soils made more compactable (48)."

Surface-active agents include a vast number of compounds with two common characteristics (3). The surfactant molecule contains a hydrophilic (water-loving) and a lipophilic (soil-loving) portion. The distinctly different physical and chemical characteristics of these two portions are very significant in enhancing the wettability of hydrophobic (hard to wet) surfaces by reducing the interfacial tensions. The water is spread over the surface rather than forming individual water beads. Black (3) has briefly reviewed surfactants as specifically related to soil problems.

Simpler surface-active agents are classified as anionic, cationic, and nonionic, while the polymeric agents are best identified as a separate group. In general, the anionic group are cheapest, nonionics about twice as expensive, and cationics about four times as expensive (3). Such cost differentials significantly influence their use. Anionics constitute almost 70 percent of the market for surface-active agents (mostly in non-agricultural uses).

Nonionic wetting agents should be used for turfgrass management purposes. Law (21) states: "Nonionic surfactants lower the surface tension of water at very low concentrations. This property has been employed to increase water infiltration into

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soils with hydrophobic properties....Aggregate stability was improved by the nonionic compounds at the higher concentrations, but was not affected significantly at the lower concentrations. Their presence improved capillary flow characteristics proportional to the amount added to the soil, and crust strengths were significantly reduced as measured by the modulus of rupture....Consequently, all effects produced by the nonionics were of a beneficial nature from the standpoint of agricultural soils." The paper (21) goes on to state that cationics can completely water-proof a soil once dried; and that anionics are not strongly adsorbed, so tend to relocate with subsequent loss of performance. Covey and Bloodworth (7), Endo *et al.* (10), and Goss (13) have indicated considerably less phytotoxicity for the nonionic materials. Therefore, the rest of this paper will only discuss the characteristics, use, and results of nonionic materials.

Beard (2) has shown that all nonionics are not the same. Some may prove phytotoxic to certain turfgrass species, particularly bentgrasses. Others may improve soil wettability and infiltration, but without any significant effect on the turf. There are some nonionic wetting agents that are safe and provide both increased soil wettability and infiltration, as well as improvement of the turf.

Law, Bloodworth, and Runkles (21), Law and Kunze (22), Valoras, Letey, and Osborn (51), and R.A. Moore, (unpublished data) showed that different surfaces--clay, sand, organic--were wetted more efficiently by different types of nonionic wetting agents. Namely, esters are most effective on sands; ethers are most effective on clays; and ethanols are most effective on organic matter. One conclusion drawn from these results was to blend the most effective types to yield a product of wide use, since turfgrass soils are always a mixture of textures. This blended product exhibited synergistic properties. In addition to wetting behavior, it is necessary to consider substantivity so that a treatment will be effective over a reasonable length of time. Research by Valoras *et al.* (51), Mistry and Bloodworth (30), and Osborn, Letey, and Valoras (39) indicated large differences between specific nonionic wetting agents in their leachability from soil mixes. Field uses show that it is possible to blend specific nonionic wetting agents to yield a product that is long-lasting (30, 39, 51), effective in all types of soils (30, 51), and has low phytotoxicity (10).

Wetting agents influence soil-moisture relations in contrasting ways. In water-repellent soils, wetting agents decrease contact angles between water and water-repellent soil grains; consequently, capillary attraction and infiltration are improved (8). Water forms a smaller contact angle with hydrophilic soils and spreads normally. If a wetting agent is added to a hydrophilic soil, both the contact angle and capillary attraction are reduced further, and though the improved wetting is less noticeable, Boodley (4), it is still improved. In the case of turfgrasses, high surface tensions result in poor wettability. An example of high surface tension is the beading of water droplets on a waxy surface or dry thatch. In these cases, strong cohesive forces among the water molecules pull inward into a bead with the assistance of the high surface tension. Surfactants act in reducing interfacial tensions by orienting between the water molecules and the soil surfaces in such a way that intimate contact between the water and soil is enhanced.

Law *et al.* (22) characterized moisture adsorption by surfactant-treated clays. The soil physical changes induced by nonionic wetting agents are related to reduced hydration of surfaces (21). Martin *et al.* (27) also indicated that improved plant growth has been related to enhanced infiltration and moisture recharge, but not to changes in moisture-holding capacity, which remains largely unchanged in soils treated with conditioners. Wooldridge (55) made similar observations.

Proper management of surfactant application to soils is greatly influenced by the type of soil to which surfactants are applied because the degree of adsorption varies from soil to soil as surfactant type is changed. Valoras *et al.* (51) studied the adsorption of two nonionic surfactants proven effective for increasing infiltration into water repellent soils. The materials they studied were alkylpolyoxyethylene ethanol (Soil Penetrant 3685) and polyoxyethylene ester blended with polyoxyethylene ether (Aqua-GRO). Aqua-GRO adsorbed more strongly and was more permanently retained than Soil Penetrant, which would be expected to leach deeper into the soil (51).

Field uses and experiment station data (34, 36) with the blended nonionic wetting agent (more consistent performance in different soil types) indicate maximum benefits in the range of 30 to 400 ppm active ingredient in the soil profile (4 to 6 inches for turfgrasses and deeper for ornamentals). Since these materials are organic and decompose in the soil, a program to maintain these levels must be followed. Where a hydrophobic soil condition already exists, the initial curative application should be higher than follow-up corrective applications. There is evidence that immediate watering-in of the wetting agent after application can be a significant factor in the effectiveness. Care should be exercised since foliar injury to turf may occur during periods of heat stress and at excessively high application rates Beard (2). One effective program, recommended by the USGA Greens Section, suggests three 170-gram (active ingredient) applications per 93 square meters early in the season. This treatment is then followed by periodic lesser treatments (227 grams per month at weekly or bi-weekly intervals) to maintain this level of 25 to 30 ppm in the root-zone area of golf course greens or tees, Zontek (56). Fairways, athletic fields, and lawn areas are treated at the rate of 227 grams per 93 square meters twice a year about three months apart.

Morgan *et al.* (32) data were obtained at a treatment level of 3 ppm, and cannot be considered as evaluating the full effects of a wetting-agent treatment. Their conclusions showed no significant effect of wetting agent treatments at this low level. Whitcomb and Roberts (54) obtained insignificant results, but their data were obtained mostly with wetting-agent solutions. Wetting agents are used to improve wettability of treated soils and, therefore, the data must be obtained on treated soils versus untreated soils.

The addition of nonionic wetting agents to soil to modify specific physical properties of soil moisture can alter other characteristics as well. Secondary effects to treated turf areas, in addition to improved wettability, can be alterations of: (a) plant growth; (b) soil chemical properties; (c) evaporation rate; (d) drainage and aeration; and (e) dew and frost incidence.

Plant Growth

The effect of surfactants on plant growth has been reviewed by Parr (42) and Parr and Norman (43), and is the subject of considerable additional literature (6,37, 46,49). Boodley (4) states that soil-moisture tension has been widely accepted as the controlling factor in a plant's ability to get water. When water is extracted by the roots, more water must flow to the root from the soil mass before further extraction can occur. The rate at which the new supply of water moves to the root is determined by both soil moisture tension and the ability of the soil to conduct water.

Soil-moisture tension and moisture content can also have an effect upon the nutrient adsorbed by turf. As a soil dries, tension increases and a greater amount of energy is required to extract nutrients from the soil. Some studies have shown that as tension increases, nutrient starvation occurs before water starvation (4). Law (20) and Price (15) showed the use of a blended nonionic wetting agent reduced the soil-moisture tension and increased water availability. Meusel's work (29) indicated that a nonionic wetting agent in the soil produced turf that was less susceptible to wilt twice as long before the plants wilted. The cell walls were thicker, intercellular air space was less, and the cutine layer was heavier in the treated samples (29). It is the opinion of this author that the reduced energy required to extract nutrients from a treated soil could result in an accumulation of carbohydrates which in turn could produce the cellular improvements. Research along these lines should be pursued.

Since one main action of wetting agents is in reducing surface tension and thus increasing wettability, they are most effective under hydrophobic soil or thatch conditions. Symptoms of a hydrophobic soil or thatch problem in turfs are most commonly expressed as localized dry spots. Initial localized dry-spot symptoms appear as scattered, irregular, relatively small patches of wilted, dying, or dead turf. Localized dry spots are more evident on intensively cultured turfs maintained at a high level of irrigation and fertilization. Turfgrass species vary in the rate at which dry spot symptoms appear. The bentgrasses and annual bluegrass are particularly susceptible, while the Kentucky bluegrasses and Bermuda grasses are much less prone to develop these symptoms (2). Goss (13) showed that two applications of a blended nonionic wetting agent eliminated all localized dry spots in lawns and greens and restored plant growth. Morgan *et al.* (33) found that even with deep aeration, localized dry spots could develop, and they used a wetting agent to eliminate them. Pelishek, Osborn, and Letey (44) reported similar results on better infiltration and uniform wetting of the root zone. Mazzeo (28) summed up the benefits of wetting agents as: (1) a more vigorous turf will develop by making water more readily available; (2) the more vigorous turf will be able to withstand hot weather and periods of drouth longer, thus reducing wilt; and (3) soil wetting agents are very beneficial in establishing and maintaining a dense turf on heavily used areas.

Frequently, irrigations are controlled by 10 to 20 percent of the turf area due to localized dry spots. The use of an effective wetting agent permits an increase in the interval between irrigations to a time when a much higher percentage of the turf area requires watering, with a saving of 30 to 50 percent of the water (29) (Tinsman and Brewer, unpublished data, Pennsylvania State University, 1960). Schramm and Lamphier (unpublished data, Pennsylvania State University, 1962) concluded that the use of a blended nonionic wetting agent has the ability to extend the effective available water range of a soil, and thus to extend the interval between watering for container stock up to 50 percent.

Some nonionic surfactants have stimulated plant growth, while others have inhibited plants in solution culture (9). Adding the same surfactants to soils has reduced or eliminated phytotoxicity, apparently because the surfactant was adsorbed on the soil grains. Surfactants added to biological systems frequently induce physical and biochemical changes. Because chemicals of widely varying structure are classed as surfactants, investigators should identify and characterize the activity of each surfactant of importance (42).

Soil Chemical Properties

Naiden and Hutchinson (36) reported an increase in potassium availability on fertilized soils treated with a blended wetting agent. The wetting agent does not contain potassium. In one study by Jones, Pratt, and Martin (17) it was shown that when certain conditioners were added to soil with potassium fertilizer, more potassium was exchangeable than when the conditioners were absent. Adsorbed polymers apparently blocked potassium migration to fixing sites (17). Since the nonionic wetting agent used in Naiden's study is known to adsorb on clay, the work of Jones *et al.* would explain the increased potassium availability in treated samples. Knoop (letter dated November 16, 1972) showed, from tissue tests, an increase in nitrogen assimilation in turf grown on plots treated with a wetting agent. Huggenberger, Letey, and Farmer (15) showed that surfactants can both increase (at 2½ times the critical miscell concentration) and decrease (12 to 25 times the cmc) the adsorption of lindane and diuron in a sandy loam soil. Bayer's work (1) clearly demonstrates that surfactants can alter adsorption of other organic materials by soil grains and thus alter soil chemistry.

Evaporation Rate

Law (20) studied fatty alcohol and a blended nonionic surfactant for controlling moisture evaporation from coarse sand and fine sandy loam soils. The nonionic surfactant lowered evaporation rates and the mechanism was believed by Law to be associated with decreased interfacial tension at the solid-liquid interface that, in turn, decreased the rate of capillary water flow to the drying soil surface. In a similar study, Mistry *et al.* (30) observed reduced water evaporation from a porous sand after adding either fatty alcohol or a blended nonionic surfactant. However, evaporation from a sandy loam was reduced only by the blended nonionic material, suggesting a strong interaction between soil texture and the evaporation suppressants, confirming the need for a blended wetting agent.

Drainage and Aeration

Naiden *et al.* (36) reported on the relief from compaction in fairways with gypsum limestone and a blended nonionic surfactant. In the first season, the wetting agent was the only treatment to show significant reduction in bulk density (compaction). Watson, McNeal, and Letey (53) attempted to improve hydraulic conductivity of salt-affected soils by adding surfactants to accelerate reclamation. They found no benefit from adding surfactants to normal soils, but only observed increased hydraulic conductivity for water-repellent soils. DeBano *et al.* (8), Letey, Pelishek, and Osborn (24), and Letey *et al.* (25) have shown that a blended nonionic wetting agent will improve infiltration, reduce run-off by 32 percent, and gave a four-fold increase in vegetation establishment. Wooldridge's work (55) showed improved infiltration, 100 percent reduction in run-off, and 300 percent reduction in sediment movement on wetting-agent treated slopes. Fletcher (11) claims that certain alkylarylpolyether alcohols, when applied to dry soils, increase rates of water percolation 20 to 50 percent. Both sandy and clay soils responded (11).

Wetting agents have significantly reduced erosion from water-repellent soils, and their selective use is recommended for highly erodible areas of this type (8,18, 19,44). Osborn *et al.* (38,40) and Mustafa and Letey (34) demonstrated that erosion was greater on untreated areas as compared with nonionic wetting-agent treated areas. Along with the 72 percent reduction in sediment movement, there was a 32 percent decrease in surface run-off and a four-fold increase in vegetation cover on the treated soils. Seed germination on sloping non-wettable soils was increased by treatments with the soil wetting agent from 0 to 86 percent (seed viability was 88 percent). In another study Mohammed and Letey (31) showed improved germination, growth, and root development for seeds treated with dilute solutions of nonionic surfactants.

Improved drainage will lessen or eliminate overwet areas where free water accumulates due to run-off and/or slow percolation. Overwet turf areas have high incidence of disease, toxic anaerobic conditions and limited usability (restricted play, cart use, mowing). The use of nonionic wetting agents to amend water and improve drainage has resulted in greater usability of turf areas, especially during rainy periods (12,41).

Dew and Frost Incidence

The reduced accumulation of dew on treated turf is the direct result of reduced surface tensions on the leaf surfaces. Reduced dew can be a significant factor in reducing the extent of disease development, particularly on closely mowed, intensively maintained turfs (2). Frost protection has been demonstrated by the reduced dew accumulation which leaves the foliage drier, and thereby prevents heavy frost layers. Protection is effective on a variety of plants down to -3 to -4° C. Lower temperatures produced damage regardless of the treatment.

CONCLUSIONS

The literature indicates that nonionic wetting agents can be utilized as an effective turfgrass cultural practice when certain types of problems develop. Specifically, the development of localized dry spots from thatch or hydrophobic soils; or overwet areas due to run-off and low percolation rates. The data show that all wetting agents are not equally effective, and that application techniques are important. Improved wettability and drainage can conserve up to 50 percent of the water required, reduce compaction, reduce wilting and the incidence of disease, and improve usage.

LITERATURE CITED

1. Bayer, D.E. Effect of Surfactants on Leaching of Substituted Urea Herbicides in Soil. Weeds 15:249-252. 1967.
2. Beard, J.B. Wetting Agents--When and How To Use Them. Ground Maintenance 5:21-24. 1973.
3. Black, W. Proceedings of a Symposium on Water-Repellent Soils (L.F. DeBano and J. Letey, Eds.) University of California, Riverside, California. Pp 133-141. 1968.
4. Boodley, J.W. Surfactants Help Make Water Wetter. Horticulture 6:39-41. 1967.
5. Boroughs, H., and C. Labarca. Turrialba 12:209. 1962.
6. Brandt, G.H. Soil Physical Property Modifiers. Pp 691-729. In Organic Chemicals in the Soil Environment, Vol. 2, Marcel Dekker, Inc., N.Y. 1972.
7. Covey, W.G. Jr., and M.E. Bloodworth. Some Effects of Surfactants on Agricultural Soils. Parts I and II. Texas A & M College, College Station, Texas. MP-529. 1961.
8. DeBano, L.F., J.F. Osborn, J.S. Krammes, and J. Letey. Soil Wettability and Wetting Agents--Our Current Knowledge of the Problem. U.S. Forest Service Research Paper PSW-43. 1967.
9. Endo, R.M. Proceedings of a Symposium on Water-Repellent Soils (L.F. DeBano and J. Letey, Eds.) University of California, Riverside, California. Pp 327-333. 1968.
10. Endo, R.M., J. Letey, N. Valoras, and J.F. Osborn. Effects of Nonionic Surfactants on Monocots. Agronomy Journal 61:850-854. 1969.
11. Fletcher, L.W. U.S. Pat. 2,867,944. 1959.

12. Anon. Extend Your Season and Profit. Golfdom 46(6):47-49. 1972.

13. Goss, R.L. Surfactant Investigations. Washington State University. 1966.

14. Gradwell, M.W. New Zealand Journal of Agricultural Research 1:834. 1958.

15. Huggenberger, F., J. Letey, and W.J. Farmer. Effect of Two Nonionic Surfactants on Adsorption and Mobility of Selected Pesticides in a Soil System. Soil Sci. Soc. Amer. Proc. 37:215-219. 1973.

16. Ionavisius, A., G.L. Maslenkova, and I.B. Revut. Sb. Tr. Agron. Fiz. 11:132 (Russian). 1965.

17. Jones, M.B., P.F. Pratt, and W.P. Martin. Soil Sci. Soc. Amer. Proc. 21:95. 1957.

18. Krammes, J.S., and H. Hellmers. Journal of Geophysical Research 68:3667. 1963.

19. Krammes, J.S., and J. Osborn. Proceedings of a Symposium on Water-Repellent Soils (L.F. DeBano and J. Letey, Eds.) University of California, Riverside, California. Pp 177-187. 1968.

20. Law, J.P., Jr. The Effect of Fatty Alcohol and a Nonionic Surfactant on Soil Moisture Evaporation in a Controlled Environment. Soil Sci. Soc. Amer. Proc. 28:695-699. 1964.

21. Law, J.P., Jr., M.E. Bloodworth, and J.R. Runkles. Reactions of Surfactants With Montmorillonitic Soils. Soil Sci. Soc. Amer. Proc. 30:327-332. 1966.

22. Law, J.P., Jr., and G.W. Kunze. Reactions of Surfactants With Montmorillonite: Adsorption Mechanisms. Soil Sci. Soc. Amer. Proc. 30:321-327. 1966.

23. Letey, J., J.F. Osborn, and R.E. Pelishek. The Influence of Water-Solid Contact Angle on Water Movement in Soils. Intl. Assn. Hydrol. Bul. 3:75-81. 1962.

24. Letey. J., R.E. Pelishek, and J.R. Osborn. Wetting Agents. California Agriculture 15(10):8-9. 1961.

25. Letey, J., N. Welch, R.E. Pelishek, and J.F. Osborn. Effect of Wetting Agents on Irrigation of Water-Repellent Soils. California Agriculture 16(12):12-13. 1962.

26. Lemon, E.R. Soil Sci. Soc. Amer. Proc. 20:120. 1956.

27. Martin, J.P., W.P. Martin. J.P. Page, W.A. Raney, and J.D. DeMeut. Adv. Agronomy 7:1. 1955.

28. Mazzeo, A.R. Wetting Agents Aid Water Penetration. Golf Superintendent. June, pp 24. 1966.

29. Meusel, H. What Makes Grass Wilt? GCSAA Intl. Turfgrass Conference. 1964.

30. Mistry, P.B., and M.E. Bloodworth. The Effect of Surface-Active Compounds on the Suppression of Water Evaporation From Soils. IASH Pub. No. 62, Pp 59-71. 1963.

31. Mohammed, E., and J. Letey. The Effect of Nonionic Surfactants on Seed Germination, Growth, Root Distribution. Agronomy Abstracts, p. 70. 1970.

32. Morgan, W.C., J. Letey, S.J. Richards, and N. Valoras. Physical Soil Amendments, Soil Compaction, Irrigation and Wetting Agents in Turfgrass Management, Parts I, II, and III. Agronomy Journal 58:525-535. 1966.

33. Morgan, W.C. Deep Aeration and Controlled Irrigation Solves Need for Reconstructing Old Compacted Greens. Western Landscaping News, August. 1964.

34. Mustafa, M.A., and J. Letey. Factors Influencing Effectiveness of Two Surfactants on Water-Repellent Soils. California Agriculture, June, pp. 12-13. 1970.

35. Mustafa, M.A., and J. Letey. The Effect of Two Nonionic Surfactants on Aggregate Stability of Soils. Soil Sci. 107(5):343-347. 1969.

36. Naiden, P.C., and F.E. Hutchinson. The Amelioration of Soil Compaction on Golf Fairways by Application of Gypsum, Limestone, and Surfactants. Master's Thesis, University of Maine. June, 1971.

37. Osborn, J.F. Proceedings of a Symposium on Water-Repellent Soils (L.F. DeBano and J. Letey, Eds.) University of California, Riverside, California Pp 297-314. 1968.

38. Osborn, J.F., J. Letey, L.F. DeBano, and E. Torry. Seed Germination and Establishment as Affected by Non-Wettable Soils and Wetting Agents. Ecology 48(3): 494-497. 1967.

39. Osborn, J.F., J. Letey, and N. Valoras. Surfactant Longevity and Wetting Characteristics. California Turfgrass Culture, Vol. 19, No. 3. 1969.

40. Osborn, J.F., R.E. Pelishek, J.S. Krammes, and J. Letey. Soil Wettability as a Factor in Erodability. Soil Sci. Soc. Amer. Proc. 32:737-739. 1968.

41. Anon. No Soggy Turf for Champion Milwaukee Braves. Park Maintenance. June, 1958.

42. Parr, J.F. Proceedings of a Symposium on Water-Repellent Soils (L.F. DeBano and J. Letey, Eds.) University of California, Riverside, California. 1968.

43. Parr, J.F., and A.G. Norman. Bot. Gaz. 126:86. 1965.

44. Pelishek, R.E., J. Osborn, and J. Letey. The Effects of Wetting Agents on Infiltration. Soil Sci. Soc. Amer. Proc. 26:595-598. 1962.

45. Price, R. Office Memo Research (Aqua-GRO) Rocky Mt. Forest and Range Exp. Sta., Ft. Collins, Colo. 1960.

46. Sauvage, F. Congr. Mond. Deterg. Prod. Tensio-actifs. Paris. 3:1122 (French). 1954.

47. Schott, H. Jour. Coll. Interface Sci. 26:133. 1968.

48. Shirley, H.G. Master's Thesis, Georgia Institute of Technology. 1965.

49. Spurnier, E.C., and J.A. Jackobs. Agronomy Journal. 47:462. 1955.

50. Valoras, N., and J. Letey. Quantitative Analysis for Nonionic Surfactants in Soil Leachates. Soil Sci. Soc. Amer. Proc. 32:737-739. 1965.

51. Valoras, N., J. Letey, and J.F. Osborn. Adsorption of Nonionic Surfactants by Soil Materials. Soil Sci. Soc. Amer. Proc. 33:345-348. 1969.

52. Watson, C.L., and J. Letey. Indices for Characterizing Soil-Water Repellency Based Upon Contact Angle-Surface Tension Relationships. Soil Sci. Soc. Amer. Proc. 34:841-844. 1970.

53. Watson, C.L., B.L. McNeal, and J. Letey. Soil Science 108:58. 1969.

54. Whitcomb, C., and E.C. Roberts. Turfgrass Growth With Wetter Water. Golf Superintendent, January, p. 24. 1967.

55. Wooldridge, D.D. Effects of Aqua-GRO on Infiltration Rates and on Certain Soil Properties. USDA Forest Service, Wenatchee, Wash. 1958.

56. Zontek, S.J. Questions From the Floor. Golf Superintendent, May, p. 7. 1972.

CUSTOM APPLICATION OF PESTICIDES BY HELICOPTER

Steve Derrick and John Latting

Through the years the golf course superintendent has had to rely not only on his vast knowledge of turfgrass, but also on the tools available for maintenance. There is quite a difference between the horse-drawn fairway units of the past and the sophisticated equipment we use now. Along with improvements in equipment, we have also witnessed the development of highly effective pesticides for turf and ornamentals. The use of these pesticides brought about the concern for the best method of application and the type of equipment to use.

While the best equipment has probably not been agreed on, I think turf researchers all concur that the best method of application is to spray the pesticide on, getting an accurate and even rate of application. In my opinion, any sprayer that accomplishes this is a good one to use, but sometimes you just cannot get that sprayer out on the course; conditions, time, or available labor just do not allow you to do it. That's when custom application by helicopter can benefit.

METHOD

As in ground sprayers, the type of helicopter and equipment can vary. We use a Bell D-1 mini-cab helicopter because of its small size and maneuverability. The ship arrives at the course on a trailer pulled by a pickup truck. Once at the course, the blades are mounted to the helicopter and it is flown off the trailer. In preparing the helicopter for spraying, you follow many of the same procedures you use with ground sprayers. All the lines are checked, nozzels are cleaned with a tooth brush, and the pump is checked and calibrated if necessary.

We insist on using 10 gallons of water per acre as a carrier when spraying turf. In field crops, as little as three gallons of water is sometimes used, but with turf we feel you need 10. To achieve this, a 33-foot boom containing 44 size 7 nozzels with size 45-whorl plates are used.

The next step involves mixing the chemical to be sprayed. The chemical is first mixed in a 1,000-gallon nurse tank with three separate sections. We then pump the spray mixture from the nurse tank into the helicopter as needed--usually 50 gallons at a time. In aerial application, as in any application method, the spray pattern is important if good results are to be obtained. We constantly check the coverage by using dark plastic squares spread over various areas on the course. This allows us to check wind drift as well as coverage.

ADVANTAGES

There are many advantages to aerial application on golf courses, some more obvious than others. Any course can benefit from its use. The degree of benefit depends on the course.

Steve Derrick and John Latting are co-owners, Professional Turf Specialties, Bloomington, Illinois.

In wet weather, aerial application allows you to apply fungicides, insecticides, or herbicides when you cannot get on the course with a ground applicator.

Application of chemicals is achieved without any wear and tear on your turf.

There is a minimum of interruption of play since most courses can be sprayed in 2 to 3 hours.

Your manpower can be utilized for normal maintenance since aerial application does not require any assistance from your staff.

Since you are charged on an acre-sprayed basis, there are no left-over chemicals to tie up your budget.

Many times pesticides are purchased, but never sprayed until next year because of weather, equipment failures, or insufficient help. This does not happen with custom aerial application.

DISADVANTAGES

Wind can effect the spray pattern. When excessive or gusty winds are present, aerial application is delayed.

Due to boom width, a helicopter cannot always spray only the fairway. Sometimes there is an overlap into the rough, and an additional acre or so is sprayed.

THE FUTURE OF HELICOPTER APPLICATIONS

The turf industry has always been a progressive group of individuals. Aerial application offers an economic, effective, and time-saving tool that I feel will be used increasingly by the superintendent. Applications will be expanded to include not only herbicides, insecticides, and fungicides, but fertilizers as well.

A CONTEMPORARY APPROACH TO AUTOMATIC IRRIGATION — CUSTOM DESIGN SYSTEM

R.R.Lamkey

With the investment in golfing facilities being measured in dollars and cents, the production of turf on a golf course becomes a heavy responsibility for the golf course superintendent. The programs of maintenance and capital improvement which he will select for the operation of the course require the utmost in professional planning. Since we will be discussing the selection of irrigation components and the planning of the system, we must first set the stage as to the reasons for initiating the capital expenditure for a water system.

The original system at Bryn Mawr was installed in the early 20's. In 1939 this system was revamped in such a manner as to preserve most of the original pipe. At that time the irrigation system was adequate for its intended purpose. Today, however, this system is no longer capable of delivering the required amount of water in a period of time and in a manner consistent with good management practices.

The age of the pipe is such that it has begun to deteriorate to a point where the cost to maintain the present system will be increasing substantially with each passing year, and in due time maintenance costs will be prohibitive. The old pumps, as well as the old pump house, will be abandoned at the completion of the new system.

To properly approach the problems involved, we felt we should employ a firm with expertise in the field of golf course irrigation. The professional approach to the irrigation system removes the major burden from the golf course superintendent. The fee for the independent firm would be 4 to 8 percent of total costs of an irrigation system--a small enough insurance investment, since we felt their opinions would be based on unbiased facts which they have obtained through previous irrigation system installations. The architectural firm will supply preliminary surveys of the present system and a determination of the needs of a new system. They will then supply design drawings for putting the system out to bid, and supply contract specification and installation details. They will help with the contract negotiations, inspect the job during installation, and prepare "as-built" drawings.

Killian and Nugent, Architects, and Hooper Engineers were selected on the basis of other work done in our area by their firms.

With the assistance of Killian and Nugent, our first consideration was to choose between an automatic irrigation system or a manual irrigation system. Due to the increased competitive labor market in which we operate, a reliable night waterman at a feasible cost is becoming more difficult to employ as each year passes. Since I feel that the night waterman is the backbone of a quality turf program, the best night waterman is the superintendent. The automatic irrigation system is the best investment. The savings not only in labor costs, but in water costs due to more efficient application and should allow us to recover the cost of automation in five to seven years.

R.R. Lamkey is Superintendent, Bryn Mawr Country Club, Lincolnwood, Illinois

The next consideration was to study our water requirements through soil maps, aerial photographs, and time limits, considering the element of watering tees, greens, approaches, and fairways in one night and a syringe capability. With these facts in hand, we chose to install a double-row irrigation system, due to the heavy clay soil with its slow infiltration rates and the fact that the fairways average 120 feet wide. Selection of heads, pipe, valves, wire, slave controllers, pumps, and central control panel equipment was accomplished on the basis of three criteria--quality, specification, and performance judged on already installed systems. From this selection process, a 50-page specification booklet was formulated for the contractor's use.

Pipe laid will be 50,800 feet, or close to 9½ miles. The remote control valves are Griswold 200E, 24-volt, with a 14-gauge wire to activate opening and closing. Every other head on the fairways will have a Rainbird Model No. 55 quick coupler head attached to it. Wire is 14-gauge, underground wire--356,500 feet equivalent to 67½ miles of wire. Also, 12,000 feet of central control wire, which is a 12-pair cable enclosed in a metal shield with a plastic sheath on the outside.

Fairway heads will be Aquadial No. 15 rubber-covered rotary pop-up head, gear driven. The green, tee, and approach head will be No. 13, Aquadial rubber-covered rotary pop-up heads, gear driven. The wires from the individual head valves will head back to four zone slave controller cabinets with 10-station Moody slave controllers with fairway heads (2 per station); green heads--4 or 5 to a green--will be individually controlled. The slave controllers will have a manual override for syringe capability from the field cabinets. The override will allow all heads on the green to operate simultaneously for watering in fertilizer or a quick syringe between foursomes on days of heavy play.

The central control panel, which will be located in the superintendent's office, has each of the four zone controllers hooked to the central by the 12-pair wire. The central cabinet (a custom-made unit by Bevco Company) will contain the basic irrigation control system. It will consist of four central programmers mounted in the cabinet, and they will be labeled individually: Greens, Tees, Approaches, and Fairways. These central controllers will be Moody Model CP-6 with a manual toggle switch for overriding the field units for the purpose of syringing from 1½ to 5½ minutes. The central will also have two 24-hour time clocks with 15-minute increments and a 14-day skip-a-day feature with one time clock to control tees, greens, and approaches, and one time clock to control fairways. The panel, which will be 4 by 8 feet, will have ten indicator lights with ten switches, each being a three-position switch. These switches are:

No. 1--Pumping Station, on-off; No. 2--Central Power, on-off; No. 3, No. 4, No. 5--Power, on-off to the three pumps; No. 6, No. 7, No. 8--Pump failure alarm condition; No. 9--Common pump house alarm indicating a vandal break-in; No. 10--Low-pressure alarm for shutdown below 95 pounds, power failure, and rainfall shutdown. Also, the panel will contain lockout circuits through an internally mounted defeat switch which will stop fairway watering from initiating until green, tee, and approach cycles have been completed, thus eliminating a low-pressure alarm.

On the end of the cabinet in a two-foot extension will be a flow metering system with a two-pen recorder showing from 0 to 1,500 gallons per minute (GPM) and pressure from 0 to 150 p.s.i., all on a seven day chart.

Other central features will be back-up system pressure gauge measuring 0 to 150 pounds; a twenty-four hour digital clock; three pump hour meters; and three ground moisture tensiometer signals which are only indicator meters not hooked into the watering functions.

The pump house is a 20- by 14-foot structure containing three Gould vertical turbine pumps--60 H.P., 25 H.P., and 7½ H.P. The pumps will sit over a wet well, 8 feet deep, which will enter from 35 feet out in the lake through three sets of strainers in a 24-inch inlet pipe set in at the bottom of the wet well. The pump house will be controlled both manually from the pump house, and from the central control panel. The pumps have a capacity of pumping 1,300 GPM. The fairway heads have the capacity of pumping 1,190 GPM. The green, tee, and approach heads have the capacity of pumping 990 GPM. The contract was given out July 1 to Muellermist of Broadview. They started construction on August 19. As of the time of this speech they have completed 14 holes.

As you can see, the system which has just been discussed has many features similar to others installed in our area and yet in many ways is distinct in that it is custom designed to Bryn Mawr Country Club and to the superintendent's wants and needs. This system as described will not fit in any other club in the country. This brings us back to the need for outside planning by an independent architectural engineering firm. Custom design for your own situation is the key to a successful irrigation system.

OVER-GROOMING IS OVER-SPENDING

Paul N. Voykin

During the last few recession years, North American golf courses, especially the private country clubs, have been in a serious financial situation because of sky-rocketing operation costs. These operational costs have increased so much that many clubs are now having difficulty keeping their heads above water. Some, as you know, have sold out to home builders and high-rise developers. Others are desperately looking to fill their decreasing memberships and reluctantly lowering their application standards in order to exist. In the Chicago area, the situation is becoming gloomy. The overall economic picture is critical. Our board of directors and management are working hard to find means of surviving for the future, without drastically cutting out the gracious living syndrome familiar to country clubs. Many concerned meetings have been held in our area and I am happy to announce that some have been productive in finding solutions to cut down operational costs. The first place they look, of course, has been where they always lose the most money--the clubhouse. I have never known a large private club to come out in the black. The best managers at most are heroes when they can maintain or reduce operational costs lower than the neighboring private country clubs.

Now what about the superintendent's situation? What about the golf course? Though I have always stated that a clubhouse, without a golf course, is nothing more than a roadside inn, with other gourmet restaurants in the area as good or better, the officials of our country clubs are also looking in our direction with a frugal eye. They are looking and saying to us: What can you as golf course superintendents do to cut down expenditures? It's your turn now.

Gentlemen, it's been our turn since I got into this profession 20 years ago. But this time the situation is obviously different and their concern is even more grave. Though we have always tried to be conservative and have held tight reins on our expenditures for many years, we too have been caught up in this inflation and have had to increase our budgets annually in order to keep up with higher wages and accelerating maintenance costs. But ironically, in spite of bigger and better budgets, we are being short-changed by the economy. We are getting less for the club dollar in every way. Our labor staffs have been reduced. The parts for our machinery are more expensive and, sad to say, less durable. Equipment and supplies are getting costlier every year and deliveries are slow. Another additional expense that has come upon us suddenly in Illinois is the new law stating that we can't burn anymore, but must haul away our dead leaves and trees to state-approved dumping areas. But all the time, without any let-up in sight, the demand for agronomic perfection and achievement keeps hammering at us. And, in spite of all these drawbacks, we have nobly succeeded with fantastic results. Our golf courses are meticulously groomed and maintained. So well in fact, that here in the midwest we are called the major league of the golf courses and have the reputation of being the best in the nation, and perhaps the world. But this continuing pressure on grooming and spotless maintenance of our superb golf courses, and trying to keep up with the inflated dollar, has increased our budgets to alarming proportions.

P.N. Voykin is Superintendent, Briarwood Country Club, Deerfield, Illinois.

We are in a serious rut, and gentlemen, I have a startling fact to reveal. You superintendents are responsible. You, whom I have admired too much and tried to emulate, have brought us to this predicament. The best among you are to blame for the situation we are in. You have set the standards too high. Let me explain quickly what I am talking about and what I think the problem is before I get shot by a friend or teacher. The problem, as I see it, is over-grooming of our golf courses. We do too much of it. The desire to improve and excel in the maintenance of our golf courses has been carried to a ridiculous and costly extreme. My contention is that if we did less grooming, the country clubs could save money and have a more challenging golf course with fewer headaches. Let me also say, at the same time, that I definitely do not advocate reverting to the European type of maintenance which really is cow-pasture grooming by North American standards. However, many golfers who travel overseas are crazy about European courses and think they have arrived at Mecca, even though they do much less grooming over there. And this fact, gentlemen, supports my arguments today. Please also understand I am not in any way talking about reducing the upkeep and management of our greens and fairways, I am talking only about possibly reducing the cost of grooming in other areas that we do so diligently maintain now. In my opinion we can let some of the areas grow a little shaggy, a little hippy so to speak, and still have a great golf course.

At Briarwood we mow our greens at a tight 3/16 of an inch and our wide bent collars at 1/2 inch or less. Our sloping aprons that meet the fairways in the front are cut at 3/4 of an inch, and then we use a triplex mower to mow around the traps and the back mounds of the green. This is all accomplished before we even come to the rough which is also mowed too short and too frequently, but my members love it that way. The fairways are mowed from 5/8 to 3/4 inch with a strip or two outside our fairways which we call intermediate rough. On a couple of holes, especially for the ladies, I mow even lower from tee to fairway because the ladies' tees on those particular holes are too far away from the "nice grass". The next example is our tees which, except for needing to be level, are really not that important. They are mowed, seeded, sodded, and fertilized too often. The tee banks are also mowed constantly so as not to look shabby. The precarious mowing of fairway bunkers and the laborious hand-mowing around all trees on the golf course also devour a lot of time and expense. At my club this never stops, and missing a day or two, because of a steady rain, gets me into a nervous dither.

I am not going to mention other numerous areas of grooming that I do at Briarwood, but I think you get the idea. I am sure there are many of you here who have to contend with other time-consuming jobs, like mowing high creek banks and cultivating shrubs around tees, over-edging of traps, pruning too high under low-branched trees, and perhaps raking traps that don't come into play, mulching every leaf that drops in Autumn, and mowing out of the way areas that really don't have to be groomed at all. I found this out a couple of years ago when I left unmowed all season two acres on the remote west side of my course. No one complained. In fact, no one even noticed--except the birds, rabbits, and butterflies. They loved the wild preservation we left untouched for them and even a few wild flowers came up. This year I was bolder. I left approximately 10 acres unmowed in the rough and this time everyone noticed and commented on the wild jungle-like elephant grass. The only way out was with a sand wedge. There were some complaints, even though most of the wild rough was remote from the playing area and the player deserved a penalty if he got into it. In the end I think they rather admired my bold move, and Briarwood's new dimension. The membership was especially proud to show this unusual hazard to guests whose remarks often were, "What the hell is that?" I won't repeat their comments when their golf balls got lost in it.

Gentlemen, what I am saying is that it's becoming too expensive to maintain 160 acres like our own backyards. The machines are going constantly from morning to night. And now I want to correct once and for all the chronic complaint by us superintendents that the membership is playing too much golf and interfering with our work. It's the other way around: we are the ones who are interfering with their play. We have spoiled the golfer rotten with expensive around-the-clock grooming. Now we have the high-cost monster looking over our shoulder with hungry fangs, and we can't afford him for a pet anymore.

Let me give you an analogy. Remember when we used to go to a barbershop to get a plain ordinary haircut? The haircut was cheap because that's all we needed to look nice and neat. But now, it's a different story. We have a thing called hair-styling. In order to look even nicer, we have our hair rinsed with a little coloring, then razor cut, styled with a hot-air blower and set with a hair net, and finally perfumed with men's hair spray. All this orgy is created by a hair stylist who, instead of recommending more use of a hair comb, recommends a special electric brush and stud hair spray. Instead of talking mostly about hockey in reply to our questions, the hair stylist tells us about hair shampoo and men's body deodorants, and even advises us that perhaps a moustache would look so-o-o nice. And we love this attention because all of us are vain to some degree or other; especially as we get older. However, all this extra grooming costs money and it's all right as long as we can afford it, but once we can't, then over-grooming is over-spending. And that applies to our golf courses.

Now the first important question you will ask is, how much will this save? Here's what I did. I went over my time sheet from April to October, 1973, and came up with these figures. Mowing rough at $3.50 per hour, 700 hours = $2,450. Mowing with a "Professional" around greens and some tees, plus the practice tee, comes to 350 hours and $1,225. Triplex around tees and green and fairway traps comes to 400 hours times $3.50 equals $1,400. Rotaries around trees comes to 250 hours which is $875. Total grooming cost is $6,000. I only chose these items because they are four maintenance items which I feel I could reduce by 50 percent or by about $3,000. It would still give the membership a presentable, but slightly tougher and definitely more interesting golf course.

Some of you, perhaps, are not too impressed by a meager savings of $3,000. That doesn't sound like much. But gentlemen, the point is, in a tough ball game, every run counts. In addition, we can accomplish other important savings, for example, in machinery. I know I could save an impressive amount on machinery over the years because, instead of having my present two or more pieces of equipment for the four jobs that I mentioned (rotaries, triplex, rough, and pro), I could get along with one piece of machinery in each category because of less demand for grooming. There is $5,000 more saved right there, not to speak of savings in mechanical upkeep and gasoline. Also, there would be a substantial saving in having to use less fertilizer and pesticides, because the grass would be longer and therefore stronger and better able to cope with the elements with less attention. Traffic damage by carts would definitely decrease. And keep in mind please, the fact that I chose only four items that I can reduce easily by a full 50 percent. There are many other maintenance aspects that can be reduced by perhaps 40, 30, or 20 percent. It all depends on how far you want to go and still have a presentable golf course.

Now the question is: Why don't I do less grooming? My reply is that unless other outstanding golf courses in my area agree to follow suit, I wouldn't try it without a solid agreement from my club. I would be afraid, I think, that unless I had it in black and white I might jeopardize my job. I am not exaggerating. The accent on quality grooming in my area is that important. I don't dare do less maintenance. The problem is also compounded by 200 other greenskeepers at my club who play other country clubs in the area and then come back and tell me what great shape your courses are in. They unfairly always compare the golf grooming, but give no thought to or have any knowledge of local conditions such as drainage, soil problems, water source, and work force, and also overlook other important variables such as budgets, equipment, and size of golf course. They also forget that the more acreage there is, the more grooming is required.

But I stand by what I have said here today. In the near future we just may have to sit down with our chairmen and boards of directors and show them with cost charts that grooming everything meticulously to the point of almost pricing ourselves right out of the game is ridiculous. And we may have to further explain that letting the grass grow a little longer and become a little more like old St. Andrews will actually make the game a little more challenging and more enjoyable. And the way golf should be--the way it was meant to be. Every other sport, such as hockey, baseball, tennis, football, etc., has regulations for size. The playing areas are the same for everyone, hard or easy depending upon your ability. Golf is the only accepted game where we can make an established area easier or difficult by maintenance procedures and techniques. We have spoiled the golfer to the point where he is possessed with always having the ball in play. It started with the touring pro, and now the member is possessed also. The playing trend has swung from accuracy to an emphasis on long-ball hitting and never landing in trouble. It's time we started back the other way. I believe the paramount objective of the founders and architects of this wonderful game was not the idea of present day "hairstyling" conditions and excessive grooming factors that are pricing us right out of the game. If they were here now, they would say to us, "Do less grooming--put skill back into the game." Our criteria should be more on how a golf course responds to par and not so much on expensive grooming.

In conclusion, I would like to say that I was significantly impressed to present this topic to you, especially after reading the recent results of the Chicago District Golf Association questionnaire. Under item 6, the majority answered yes to the question, "Do you feel that green maintenance and capital improvements may require future limitations due to financial pressure and the energy crisis?" In answer to the question, "In what areas would you feel limitations might first be applied?", the majority from our Chicagoland Golf Courses answered, "Less golf-course grooming."

LANDSCAPE SESSION

ZOYSIA AND TALL FESCUE — ALTERNATIVES TO KENTUCKY BLUEGRASS

John H. Dunn

We are currently besieged by a wide array of new, elite Kentucky bluegrass varieties with names which suggest varying degrees of beauty (e.g., Glade), durability (e.g., Geronimo), dependability (e.g., Touchdown), and superiority (e.g., Vantage). One can only agree that in the proper environment and with appropriate management a luxurient carpet of turf can be established and maintained with many of these varieties. However, consider the word environment for a moment, particularly as it applies to the midwest transition area. Here the environment is rather harsh for the culture of any grass as temperatures range from sub-zero in the dead of winter to roasting hot in mid-summer. For Kentucky bluegrass, the time of trial is summer when the species is highly susceptible to disease, heat, and drouth stress. The last stress factor may cause us even greater concern in the near future since some individuals are predicting intervals of prolonged drouth stress, like that of summer 1974, over the next three to eight years. Also, some elite bluegrasses may require up to 6 lb. N per 1,000 sq. ft. per year for best appearance which puts another small dent in the pocket in light of the recent jump in fertilizer prices. We are, of course, not recommending that bluegrass lovers give up the species. In fact, intensive breeding efforts in recent years have given us varieties which are better adapted to the transition zone than many of the older common and elite types. However, perhaps we should give more consideration to the alternatives.

SOME ALTERNATIVES

There are some individuals who would choose to give up the lawn altogether, and in its place put an easily kept expanse of cement or stone. I have seen both and I am sure that professional turf managers have at times been tempted to use this approach. Other individuals have chosen the plastic carpet (synthetic turf), but even some brands of this will fizzle in a tough environment. Also, a dead plastic carpet does not "turn on" the true aficionado of nature. Most turf lovers prefer a living alternative.

TALL FESCUE

Tall fescue is one of at least two possibilities. This, like Kentucky bluegrass, is a cool-season species and, like the latter species, it originated on the European-Mid-East continent eons ago. Tall fescue is an extremely hardy grass with a tough leaf tissue and a wide tolerance of soil textures and pH. It grows well in sunny or moderately shady areas, and has summer heat and drouth tolerance which must be rated excellent among the cool-season species. During this past summer, green tall fescue varieties stood out like a sore thumb next to elite, but dried-out Kentucky bluegrasses in non-irrigated test plots at Columbia. We commonly recommend it in Missouri for use on lawns without irrigation facilities and for school grounds and athletic fields.

J.H. Dunn is Associate Professor, Department of Horticulture, University of Missouri.

There are some serious disadvantages in culturing tall fescue which we cannot overlook. Varieties of the species tend to become clumpy if not established and managed properly, mostly because it lacks rhizomes and therefore is not a spreader like Kentucky bluegrass. On occasion it may be damaged by warm weather diseases like Rhizoctonia, especially if over-managed. Also, its leaf texture is described as coarse compared with Kentucky bluegrass.

Most of these disadvantages can be overcome with a combination of proper management and breeding of improved varieties. We at Missouri have been striving for more than seven years to develop a variety or varieties which will offer improved features compared with the typically coarse varieties which are available now. These features include improved disease tolerance, finer leaf texture, and a rhizomatous or spreading habit. We feel we are getting close to achieving our objectives, and with continued effort we should have something promising in the near future.

However, with proper establishment and management procedures, we can even grow a good turf with the old tall fescue workhorse, Kentucky 31. A fertile seedbed is important and should include ample phosphorus and potassium. For lawn turf, heavy seeding of 8 to 10 lb. per 1,000 sq. ft. is preferred in contrast to former pasture recommendations as low as 2 to 16 lb. per acre. This will result in a dense turf which helps compensate for the lack of rhizomes in Kentucky 31. Also, competition between plants gives a finer textured leaf and a more pleasing turf appearance. Lighter rates of seeding may be used where establishment of a ground cover is the primary objective and turf appearance is of secondary importance. Yearly maintenance should include mowing turf to 2½ to 3 inches for lawn turf and fertilizing with 3 to 4 lb. N per 1,000 sq. ft. per year, mostly in the fall.

ZOYSIA--A SECOND ALTERNATIVE

A second "living" alternative is *Zoysia japonica*, a turfgrass species which is distinctly different from tall fescue. This is a warm-season grass which prefers warm nights and days with temperatures hovering near 100° F. Cold tolerance of this species is tops among the warm-season grasses. This may be attributed to its origin in Korea-Manchuria where sub-zero temperatures in winter are common. The tough-leaved species also has good tolerance to foot traffic, some shade tolerance, and generally excellent disease and insect tolerance in the midwest. The established turf is dense and weed free. It will grow on a wide range of soil types, although it seems to prefer the "heavier" soils. The preferred variety in the midwest area is Meyer, a japonica selection of moderate leaf texture. A few new experimental selections being developed at Kansas State may give some improvement over Meyer in future years.

With so many good features, one might ask if this grass has any shortcomings. Unfortunately, there are several, including the usual practice of establishing the grass vegetatively by sprigging or plugging. This necessary and expensive practice can be attributed to the wide variation in seedling types that occur with seeding and also to a thick seed coat which may result in a low percent of germination. After planting, growth is slow and some pampering and coaxing is needed to encourage more rapid spreading. Weed control to prevent competition to the developing turf is a requisite for quick zoysia establishment.

Later, the permanent turf may develop a heavy layer of thatch, particularly if overmanaged, and mechanical thinning is occasionally needed to keep the turf in top condition. Also, zoysia turf should be mowed with a heavy-duty, often expensive, reel-type mower, although I have seen acceptable results with rotary mowing at 1 inch or higher, providing the engine is of sufficient size. Zoysia loses color with heavy frost and will remain dormant for 6 to 7 months in the midwest. Some individuals find the yellow-brown color of the dormant turf attractive in winter; others do not. Also, winter weeds may be a nuisance in the dormant turf, but these are easily controlled with herbicides.

When establishing this grass, it is best to begin with a clean, weed-free seedbed. Sprigs or plugs should be set on six-inch centers or closer, depending upon the planting technique, in late spring to allow for maximum spread during the summer. Immediate and judicious watering of new plantings is important to prevent initial shock and insure a quick take-off. Failure to water zoysia thoroughly when planting during hot weather may slow its growth for several weeks. Mulching and/or overseeding with a perennial grass (e.g., ryegrass) may be necessary on slopes to hold soil until zoysia has filled in.

The developing turf should be fertilized heavily with a total of 8 to 10 lb. N per 1,000 sq. ft. over the summer until mid-August. Fertilization should be discontinued at this time to allow the grass to harden for the coming winter. During the period of fertilization, weed control should be practiced to prevent competition as noted earlier. We have used 2,4-D for broadleaf control and several preemergence herbicides for crabgrass control in newly planted Meyer zoysia with good success at Columbia. If the foregoing practices are followed, the turf may be well established after two summers.

Fertilization of established zoysia turf will require about 1 to 3 lb. N per 1,000 sq. ft. over the growing season, depending on your preference for green color and assuming that phosphorus and potassium are kept at a moderate to high level. A mowing height of 3/4 to 1 inch is preferred for the most attractive zoysia turf. Mechanical dethatching will be necessary from time to time, but this can be minimized by using moderate fertilization.

REFERENCES

Beard, J.B. Turfgrass: Science and Culture. Prentice-Hall, Inc., Englewood Cliffs, N.J. 1972.

Daniel, W.H. Zoysia--Observations and Experiences in the 60's. Proceedings of the 11th Annual Missouri Lawn and Turf Conference. Pp. 30-43. 1970.

Juska, F.V., A.A. Hanson, and A.W. Hovin. Kentucky 31 Tall Fescue--a Shade-Tolerant Grass. Weeds, Trees, and Turf. January. Pp. 34-35. 1969.

Lobenstein, C.W. Zoysia at Alvamar Hills. Proceedings of the 11th Annual Missouri Lawn and Turf Conference. Pp. 28-30. 1970.

Madison, J.H. Practical Turfgrass Management. Van Nostrand Reinhold, New York, N.Y. 1971.

Record, F.L. Zoysia--a Turf for Transition Zone Fairways. USGA Greens Section Record 9(4):5-6. 1971.

EFFECTS OF MOWING HEIGHT, MOWING FREQUENCY, AND FERTILIZATION ON KENTUCKY BLUEGRASS TURF

G.S. Schinderle and A.J. Turgeon

Mowing is a fundamental cultural practice that distinguishes turfgrass from other plant systems. Numerous effects of mowing height and frequency, and fertilization have been reported. Harrison (4) concluded that Kentucky bluegrass could not be maintained satisfactorily at less than 3/4-inch cutting height due to its reduced tolerance to drouth, diseases, heat, cold, and competition from annual bluegrass, crabgrass, and other weeds. Goss and Law (3) determined that close, frequent mowing resulted in less root and shoot growth. Juska *et al.* (5) reported that high nitrogen fertilization and close mowing (3/4 inch) inhibited rooting and rhizome growth, while low nitrogen and high mowing (2 inches) resulted in the greatest root and rhizome production. Crider (2) determined that turf should be mowed frequently enough so that no more than 30 to 40 percent of the leaf area is removed at any one mowing; otherwise, root growth would cease temporarily. However, Madison (6) concluded from studies with Seaside creeping bentgrass that a rest period between daily mowings was necessary to stimulate growth by allowing a build up of carbohydrate reserves in the plants. Thus, some confusion exists regarding the effects of mowing frequency on turfgrass quality. Removal of too much foliage from infrequent mowing is believed to cause severe shock to the physiological balance of the turfgrass plants (1), while removal of small amounts of foliage too frequently may result in a weak turf which lacks adequate vigor and recuperative potential (6).

The purpose of this research was to study the interaction of mowing frequency and mowing height at four fertilization levels in a Kentucky bluegrass turf to determine the importance of mowing frequency on turfgrass quality.

MATERIALS AND METHODS

A two-year-old turf of 'Pennstar-Fylking-Prato' Kentucky bluegrass was clipped at cutting heights of 0.75, 1.5, or 3 inches, once, three times, or five times per week with clippings removed, beginning in June, 1974. Fertilization levels were 0, 0.5, 1, or 2 pounds of nitrogen (N) per 1,000 square feet (M) per month (Mo). Irrigation was performed as needed to prevent wilt. Plot size was 6 by 10 feet. Data on clipping yield, density, rooting and rhizome development, thatch, disease incidence, and turfgrass quality were taken in August and again in October, 1974.

RESULTS AND DISCUSSION

Results were fairly consistent with those reported in similar studies (3,4,5); however, several peculiar developments were observed. First, *Rhizoctonia* brown patch incidence was extensive in all plots mowed at 3/4 inch once per week (Table 1). Disease severity was less where mowing frequency was three times per week, and essentially no disease was evident in plots mowed five times per week at 3/4 inch, regardless of fertilization level. The disease symptoms were evident for only about two weeks, and their disappearance was associated with the occurrance of cooler weather in mid-August.

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The clipping yield of turf mowed five times per week (Monday through Friday) at 3/4 inch was least on the second day of mowing in August after a weekend rest period (Table 2). This directly conflicts with previously reported data indicating that clippings should be greatest on the second mowing day (Tuesday) due to a build up of carbohydrates during the weekend rest period that stimulates a burst of new growth following the Monday mowing (6). In October the yield from the Tuesday mowing was generally higher than for the rest of the week (Table 3). Thus, the build-up of carbohydrate reserves must be dependent upon existing climatic conditions and growth rate. The confusion concerning mowing frequency might be resolved through recognition of the interaction of defoliation and climatic conditions. Severe defoliation under mid-summer stress conditions may be injurious to the turf because sufficient carbohydrate reserves do not exist to support a resurgence of new growth. In contrast, the slower growth rate and higher carbohydrate reserves existing in October allow relatively infrequent mowing and severe defoliation without a loss in turfgrass vigor or quality.

Total clipping yield was generally greater from plots mowed only once per week; yet, turfgrass recovery from fertilizer burn in plots mowed at 3/4 inch and receiving 2 pounds N per 1,000 square feet in July was fastest where mowing frequency was five times per week and slowest in plots mowed only once per week. Thus, clipping yield is not always a good indicator of turfgrass recuperative ability since severe defoliation at low mowing frequencies in summer may shock the turf resulting in a loss of vigor.

Turfgrass quality was usually best at lower fertilization levels in August, but at higher levels in October (Table 4). Higher fertilization during the fall resulted in deeper color and more growth. This suggests that fertilization was important in preventing the turf from going into complete winter dormancy prematurely.

In conclusion, a 'Pennstar-Fylking-Prato' Kentucky bluegrass turf should be maintained under light fertilization and relatively frequent mowing during summer to provide best quality and recuperative potential, but in the fall the turf should be fertilized more to maintain color but mowing frequency can be reduced substantially without reducing quality or vigor.

LITERATURE CITED

1. Beard, J.B. Turfgrass: Science and Culture. Prentice Hall, Inc., Englewood Cliffs, New Jersey. 1973.
2. Crider, F.J. Root Growth Stoppage Resulting From Defoliation of Grasses. U.S. Technical Bulletin No. 1102, pp 1-23. 1955.
3. Goss, R.L., and A.G. Law. Performance of Bluegrass Varieties at Two Cutting Heights and Two Nitrogen Levels. Agronomy Journal 59:516-518. 1967.
4. Harrison, C.M. Effect of Cutting and Fertilizer Applications on Grass Development. Plant Physiology 6:669-684. 1931.
5. Juska, F.V., J. Tyson, and C.M. Harrison. The Competitive Relationship of Merion Bluegrass as Influenced by Various Mixtures, Cutting Heights, and Levels of Nitrogen. Agronomy Journal 47:513-518. 1955.
6. Madison, J.H. Mowing of Turfgrasses III. The Effect of Rest on Seaside Bentgrass Turf Mowed Daily. Agronomy Journal 54:252-253. 1962.

Table 1. Effect of Mowing Height and Frequency, and Fertilization on the Incidence of Rhizoctonia Brown Patch Disease in a 'Pennstar-Fylking-Prato' Kentucky Bluegrass Turf in July, 1974[a]

Mowing height (in)	Fertilization (lb. N/1,000 sq. ft./mo.)	Mowing frequency 1/wk.	3/wk.	5/wk.
.75	0	7.0	4.0	1.0
.75	.5	6.5	3.0	1.5
.75	1.0	7.0	4.0	1.0
.75	2.0	7.0	4.5	1.0
1.50	0	1.0	1.0	1.0
1.50	.5	1.0	1.0	1.0
1.50	1.0	1.0	1.0	1.0
1.50	2.0	1.0	1.0	1.0
3.00	0	1.0	1.0	1.0
3.00	.5	1.0	1.0	1.0
3.00	1.0	1.0	1.0	1.0
3.00	2.0	1.0	1.0	1.0

[a]Disease rating based on a scale of 1 through 9 with 1 representing no disease and 9 representing complete discoloration of the turf.

Table 2. Effect of Mowing Height and Frequency on Clipping Yield of a 'Pennstar-Fylking-Prato' Kentucky Bluegrass Turf in August, 1974

Mowing height (in.)	Fertilization (lb. N/1,000 sq. ft./mo.)	Mowing frequency 1/wk.	3/wk.			5/wk.				
		(g. dry wt./60 sq. ft.)								
.75	0	96	46	36	33	29	9	9	8	11
.75	.5	352	104	63	57	112	28	40	31	35
.75	1	332	116	71	48	131	24	30	38	28
.75	2	202	113	64	58	91	29	33	25	30
1.50	0	105	33	20	14	31	13	12	13	12
1.50	.5	402	129	83	58	94	31	38	19	25
1.50	1	530	102	86	74	132	41	49	24	32
1.50	2	437	117	84	62	107	39	42	22	29
3.00	0	70	30	22	23	45	16	15	16	15
3.00	.5	255	106	59	51	96	30	22	29	28
3.00	1	274	126	62	66	131	33	33	32	34
3.00	2	211	108	53	50	91	35	23	26	27

Table 3. Effect of Mowing Height and Frequency on Clipping Yield of a 'Pennstar-Fylking-Prato' Kentucky Bluegrass Turf in October, 1974

Mowing height (in.)	Fertilization (lb. N/1,000 sq. ft./mo.)	Mowing frequency 1/wk.	3/wk.			5/wk.				
.75	0	28	13	8	9	10	5	2	2	3
.75	.5	75	28	17	11	33	19	10	6	7
.75	1	88	40	21	16	38	13	6	9	9
.75	2	91	38	24	16	30	18	10	7	6
1.50	0	25	8	4	4	7	4	1	1	1
1.50	.5	54	31	17	13	23	8	6	3	4
1.50	1	68	40	24	15	35	16	8	3	5
1.50	2	99	35	18	14	37	13	9	4	6
3.00	0	16	3	3	1	6	5	3	4	2
3.00	.5	64	24	15	13	21	9	5	4	2
3.00	1	71	32	19	9	32	13	6	6	4
3.00	2	70	32	16	11	24	14	8	1	3

Table 4. Effects of Mowing Height and Frequency, and Fertilization on the Visual Quality of a 'Pennstar-Fylking-Prato' Kentucky Bluegrass Turf in August and October, 1974[a]

Mowing height (in.)	Fertilization (lb. N/1,000 sq. ft./mo.)	Mowing frequency 1/wk.		3/wk.		5/wk.	
		Aug	Oct	Aug	Oct	Aug	Oct
.75	0	7	7	7	7	6	6
.75	.5	7	3	5	3	4	3
.75	1.0	7	2	6	3	3	3
.75	2.0	8	3	8	3	7	2
1.50	0	5	5	4	6	3	5
1.50	.5	3	3	1	3	3	2
1.50	1.0	4	2	2	2	4	3
1.50	2.0	7	2	6	1	4	2
3.00	0	4	6	4	5	2	4
3.00	.5	5	4	3	3	3	3
3.00	1.0	5	3	3	3	4	3
3.00	2.0	4	3	4	2	3	2

[a]Quality ratings are based on a scale of 1 through 9 with 1 representing best and 9 representing poorest.

ORNAMENTAL AND TURFGRASS INSECTS AND THEIR CONTROL

Roscoe Randell

Insects infesting shade trees, flowering trees, and shrubs may be grouped into categories. Some of these groups are discussed below.

MISCELLANEOUS INSECTS

Scale insects are characterized by the presence of many small, usually inconspicuous animals fastened to the bark of tree or shrub twigs and limbs. A waxy, protective coating covers the older scale. Limbs encrusted with scale are usually weakened or killed. In general, scale insects are most easily killed in the immature or "crawler" stage with an application of malathion or similar insecticide.

Aphids appear on many different trees and shrubs, plus some bluegrass areas. There are many species of aphids. They are soft-bodied, rapid reproducers, and vulnerable to many predators, parasites, and diseases. Spraying for insect control can decrease beneficial insects, allowing aphids to increase. Aphids are easily controlled by thorough coverage sprays containing malathion or similar insecticides.

Webworms and tent caterpillars are larvae or immature stages of moths. They feed on tree foliage and at the same time spin nests around tree branches or in crotches of limbs. Their damage is only defoliation of part of the tree and rarely is severe. Treatment is justified if worms are numerous. Control is less effective when tents or webs have been constructed protecting the worms. Sprays containing Sevin, malathion, or diazinon are effective.

Cankerworms or "inch-worms" are measuring worms or loopers that defoliate trees, especially elms, in the spring months. Sprays containing Sevin or *Bacillus thuringiensis* will control cankerworms.

Leaf feeding beetles feed on leaves of various trees. For example, both the adult and larvae of elm leaf beetles feed on the foliage of elms. Numbers build up over a few years and, when the beetles are numerous, sprays containing Sevin or malathion will control them.

Bagworms feed on evergreens and broadleaf trees. While feeding, they construct spindle-shaped bags in which they live. Spraying in June and early July will control young bagworms. Use Sevin, *Bacillus thuringiensis*, or malathion.

Borers attack the trunk and limbs of trees, especially young trees. Flat-headed apple borers girdle young, newly set trees, particularly soft maple. Bronze birch borers attack white and paper birch trees. Locust borers attack black locust trees. All of these borers exit from the tree as an adult beetle and then return as a newly hatched borer to the trunk of the tree. Successful chemical control is applying an insecticide and timing it to kill newly hatched borers. Borers attacking flowering fruit trees such as flowering cherry, etc., as well as lilac,

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dogwood, and ash trees, are controlled effectively with Thiodan or Dursban. Dursban is labelled for use on ornamentals, but not specifically on the above trees. Cygon and Guthion are suggested for borer larvae. Timing is very important in borer control.

Mites are almost always present on trees and shrubs. Both pest and predator mites can be seen on foliage with the aid of a hand lens. Predator mites can be reduced or killed off with insecticides such as Sevin. Pest mites will then build up. Pest mites, if numerous and doing damage, should be reduced with a miticide such as Kelthane or acaralate.

TURFGRASS INSECTS

Sod webworms, cutworms, and armyworms are caterpillars of moths and feed at or near the base of a grass plant. They become more numerous throughout the summer. Sevin, Dursban, Proxol, Dylox, or diazinon will control these worms.

Chinch bugs suck plant juices from grass blades. Various ages and colors of bugs can be found in large numbers. Colors include red and white, black, and black and white. Dursban, Aspon, Proxol, and diazinon will control these bugs.

Grubs, especially annual white grubs, feed on grass roots, thus leaving the sod cut loose from the soil. Diazinon or Proxol applied in late summer, if damage is visible, will control annual white grubs.

1975 INSECT CONTROL SUGGESTIONS FOR COMMERCIAL APPLICATORS FOR TREES, SHRUBS, AND TURFGRASS

Tree and Shrub Insects

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a/]
Aphids	malathion diazinon	1 1	When aphids are numerous.
Ash borer	endosulfan	1	Apply in mid-June and repeat four weeks later.
Bagworm	malathion carbaryl *Bacillus thuringiensis*	1 2 follow label directions	Spray foliage thoroughly about June 15 while worms are still small.
Birch leaf miner	malathion diazinon Imidan	1 1 3/4	Spray foliage thoroughly when miners first appear. Repeat 10-12 days later.
Black vine weevil	chlordane endosulfan	1 1	Spray foliage thoroughly in mid-May when adults are on needles. Allow spray to runoff onto soil under shrubs.
Bronze birch borer	dimethoate	1/2	Spray bark of trunk and limbs in early June and repeat three weeks later.
Cankerworms	malathion diazinon carbaryl Imidan *Bacillus thuringiensis*	1 1 2 3/4 follow label directions	Spray when worms are still small as leaf buds are opening in spring.
Cicada	carbaryl	2	Spray foliage when egglaying begins. Repeat every five days while adult cicadas are present.
Cooley spruce gall aphid	malathion diazinon	1 1	Apply in late September or in early spring just before buds swell.
Cottony maple scale	malathion diazinon	1 1	Spray in late July after crawlers have hatched and repeat ten days later.

a/ Treatment dates are listed for central Illinois. In southern Illinois apply two weeks earlier and in northern Illinois two weeks later.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a/]
Dogwood borer	endosulfan	1	Apply in mid-May and repeat four weeks later.
Eastern spruce gall aphid	malathion diazinon	1 1	Apply in late September or in early spring just before buds swell.
Eastern tent caterpillar	malathion diazinon *Bacillus thuringiensis*	1 1 follow label directions	Spray areas of tree where nests first appear in early spring.
Elm bark beetles	methoxychlor	...	Contact Section of Applied Botany and Plant Pathology, Illinois Natural History Survey, Urbana, Illinois 61801, for information on Dutch elm disease control.
Elm cockscomb gall	malathion	1	Usually no control is necessary.
Elm leaf beetle	carbaryl malathion diazinon	2 1 1	
Eriophyid mites	chloropropylate dicofol	1/2 1/2	Spray only when injury is observed. Usually control is not necessary.
Euonymous scale	malathion diazinon	1 1	Spray in early June. Make four applications 10-12 days apart.
European elm scale	malathion	1	Apply in June and repeat later.
European pine sawfly	carbaryl malathion diazinon	2 1 1	Spray when worms are present and feeding on the needles.
European pine shoot moth	dimethoate	1/2	Spray ends of branches thoroughly in early June.
Flat-headed apple tree borer	dimethoate azinphosmethyl	1/2 1/2	Spray in late May and repeat twice at three-week intervals. Keep trees in vigorous growing condition. Wrap trunks of newly set trees with paper or burlap.
Fall webworm	carbaryl malathion diazinon *Bacillus thuringiensis*	2 1 1 follow label directions	Spray nests on webbed areas in trees in late summer.

a/ Treatment dates are listed for central Illinois. In southern Illinois apply two weeks earlier and in northern Illinois two weeks later.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Forest tent caterpillar	carbaryl	2	Spray when caterpillars are present.
	malathion	1	
	diazinon	1	
Gouty oak gall	...	...	Prune out infested branches and destroy.
Hackberry psyllids	malathion	1	Apply in late May. This insect rarely damages trees.
	diazinon	1	
Hawthorn leaf miner	malathion	1	Treat in mid-May or when first sign of leaf-browning appears.
	diazinon	1	
Hawthorn mealy bug	malathion	1	Apply when insects are numerous.
	diazinon	1	
	dimethoate	1/2	
Holly leaf miner	dimethoate	1/2	Spray foliage in late May or early June when leaf miners first appear.
Honey locust pod gall	...	...	No chemical control is necessary.
Lacebug	carbaryl	2	Spray when bugs are numerous.
	malathion	1	
Leaf crumpler	malathion	1	Spray in late May and again in late August.
	diazinon	1	
Leafhoppers	carbaryl	2	Spray when hoppers are numerous on foliage.
Lecanium scale	diazinon	1	Apply to infested trees in mid-June and repeat two weeks later.
	malathion	1	
Lilac borer	endosulfan	1	Apply in mid-May and repeat four weeks later.
Locust mite	dicofol	1/2	Apply in early spring just before leaves appear. Repeat spray two weeks later.
Magnolia scale	malathion	1	Treat in late September or early spring when buds are opening.
	diazinon	1	
Maple bladder gall	dicofol	1/2	Chemical control usually not necessary. If infestation has been severe, spray tree as leaf buds are opening in spring.
Mimosa webworm	malathion	1	Spray in late June or when webs first appear. Repeat in August for second generation.
	diazinon	1	
	Bacillus thuringiensis	follow label directions	

a/ Treatment dates are listed for central Illinois. In southern Illinois apply two weeks earlier and in northern Illinois two weeks later.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a/]
Nantucket pine moth	dimethoate	1/2	Spray ends of branches in early May.
Oak kermes	malathion	1	Apply when crawlers appear on foliage in early July.
Obscure scale	superior oil	2 gallons	Apply in late October or in early spring just prior to leaf emergence.
Oystershell scale	malathion diazinon dimethoate	1 1 1/2	Apply in early June and repeat 10-12 days later. Repeat sprays again in early August in central and southern Illinois.
Peach tree borer	endosulfan	1	Spray thoroughly bark of trunk and limbs in mid-June and repeat four weeks later.
Pine bark aphid	malathion diazinon	1 1	Spray when aphids are present, usually in May and later.
Pine needle scale	malathion diazinon	1 1	Apply spray in late May if trees are infested.
San Jose scale	superior oil	2 gallons	Apply to bark of trunk and limbs in spring prior to leaf emergence.
Spider mites	dicofol tetradifon chloropropylate	1/2 1/2 1/2	Spray when mites are numerous. Especially serious on juniper.
Spittle bug			No chemical control necessary.
Taxus mealy bug	malathion	1	Spray foliage with force when insects are present. Repeat two weeks later.
Thrips	malathion diazinon	1 1	Spray privet when thrips are numerous.
Tuliptree scale	superior oil malathion	2 gallons 1	Apply oil in late spring before leaves emerge. Apply malathion in late September.
Yellow-necked caterpillar	malathion diazinon carbaryl	1 1 2	Spray foliage on which caterpillars are feeding, usually in late July.
Zimmerman pine moth	malathion	2	Spray bark and foliage in mid-August and again two weeks later.

a/ Treatment dates are listed for central Illinois. In southern Illinois apply two weeks earlier and in northern Illinois two weeks later.

Insects	Insecticide	Lb. of active ingredient per acre	Timing of application
Ants and soil-nesting wasps	diazinon spray	4	Apply when insects are present.
Aphids (greenbug)	malathion spray	1	Apply only when aphids are present.
	diazinon spray	1	
Armyworms and cutworms	carbaryl spray or granules	8	Treat when worms are present.
	trichlorfon spray or granules	5	
	diazinon spray or granules	4	
	chlorpyrifos spray or granules	1	
Chiggers	diazinon	1	Apply to grass area where chiggers have been a problem.
	malathion	1	
Chinch bugs	chlorpyrifos spray	1	Spray when bugs are numerous.
	trichlorfon spray	5	
	Aspon spray	10	
	diazinon	4	
Grubs, including true white, annual white, Japanese beetle, green June beetle	diazinon spray or granules	5	Treat damaged areas and where grubs are present in soil. Water-in very thoroughly.
	trichlorfon spray	8	
Leafhoppers and grasshoppers	carbaryl spray	4	Treatment not usually necessary unless hoppers are numerous.
Millipedes	carbaryl spray	8	Apply to turf where millipedes are migrating across area.
	diazinon spray	4	
Slugs	Mesurol bait		Apply by scattering in grass.
	Zectran bait		
Sod webworms	carbaryl spray or granules	8	Apply in late July or August when worms are present. Use 120 gallons of water per acre.
	diazinon spray or granules	4	
	chlorpyrifos spray or granules	1	
	trichlorfon spray	4	
	Aspon spray	10	

INSECTICIDES: NAMES AND SOME COMMERCIAL FORMULATIONS

Common name	Trade names	Formulations
azinphosmethyl	Guthion	50% W. 5% G.
Bacillus thuringiensis	Biotrol, Dipel, Thuricide	
carbaryl[a/]	Sevin	80% S. 50% W.
chlorpyrifos	Dursban	2 lb./gal. 1% G.
diazinon[b/]	Spectracide	4 lb./gal. 25% E.C. 50% W. 14% G.
dicofol	Kelthane	18.5% E.C. 18.5% W.
dimethoate[c/]	Cygon, De-Fend	2 lb./gal. 25% W.P.
endosulfan	Thiodan	2 lb./gal. E.C. 50% W.
malathion[d/]	Cythion	50-57% E.C. 25% W.
superior oil	many brands	...
trichlorfon	Dylox, Proxol	80% W. 4 lb./gal.
	Aspon	13% E.C. 6 lb./gal.
	Imidan	50% W.

a/ Do not use on Boston ivy.
b/ Do not use on ferns or hibiscus.
c/ Do not use on chrysanthemums.
d/ Do not use on canaert red cedar.

Note: E.C. = emulsion concentrate; W. = wettable powder; G. = granules; S. = sprayable powder.

SELECTING ORNAMENTAL PLANTS FOR USE IN THE LANDSCAPE

D.J. Williams

Landscape plants? Why? This is an important question one should ask when selecting trees and shrubs for the landscape.

The first and most obvious reason for the use of landscape plants is for their aesthetic characteristics. The most popular aesthetic characteristic of plants is their flowers. Other aesthetic characteristics such as fruit, foliage, bark, and form should also be considered when selecting plants for landscape use. A list of plants hardy in Illinois and grouped by their aesthetic characteristics is presented in Table 1. Plants should be selected which have more than one season of interest. An example would be flowering dogwood (*Cornus florida*) which exhibits a spring flower display, good red fall color, a red fall fruit display, and an interesting winter outline.

Aside from their aesthetic value, plants can also be used for many functional reasons. Some functions performed by plants are erosion control, screening, traffic control, alteration of micro-climate, biological monitoring of air pollutants, and air purification.

Plants selected for erosion control should have shallow fibrous root systems which spread throughout the soil. Low-growing plants which have aerial plant parts, such as leaves and stems, in contact with the soil are excellent for erosion-control useage. Growth rate is important for it is necessary to get the surface of the soil covered as rapidly as possible for good erosion control.

The use of plants for the screening of objectionable views, wind, and people has long been practiced. Sound has become a major pollution problem in the United States, prompting studies to determine the effectiveness of plants as sound barriers. "Soft" barriers of tree-shrub-grass combinations have been shown to reduce the apparent loudness of sounds approximately one-third that of "hard" pavement surfaces. The effectiveness of plants as noise screens is affected by placement, density, size of plants, and the width of plant belts. The closer to the source of a particular sound, the more effective plants will be in reducing the apparent loudness of the sound. As the size and density of individual plants and plant belts increase so does their ability to reduce noise. A knowledge of outdoor sound propagation and experience is necessary to make valid judgements on the use of plants for noise reduction.

Random movement through an area may cause damage and reduce environmental quality. Plants can replace fences, chains, posts, and wires, providing barriers for traffic control which enhance the visual quality of the environment. Characteristics of plants which increase their ability to control traffic are thorns, density, flexibility of stems, and multi-stemmed growth habit. Thorns are potentially dangerous, therefore, plants with this character should be used judiciously and kept away from areas used by children.

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Modification of micro-climates is another important function performed by plants. Temperature control by vegetation occurs due to reflection of solar radiation (shade) by foliage or due to an actual cooling of the atmosphere surrounding plants by evapo-transpiration. Studies have shown that air temperatures in city parks are often 10° F. cooler than in surrounding business districts. Trees can reduce air temperatures along city streets as much as 2 to 3° F.

Plants can be used to monitor atmosphere contaminants. They can be placed throughout cities and used in conjunction with instrumental methods to detect air pollutants. Sensitive indicator plants are given in Table 2.

In addition to their potential as monitors of air pollutants, plants can also play an important role in air purification. Calculations based upon sulfur dioxide uptake of Douglas-fir indicate that a tree with a 15-inch diameter trunk can potentially remove 43.5 pounds of sulfur dioxide a year. An acre of similar size trees has the potential of removing 3.7 tons of sulfur dioxide per year. It should be noted that the potential of plants as secondary air filters is significant, but cannot substitute for primary pollution control at the source.

Whether plants are chosen for their aesthetic or functional attributes, factors such as final size, hardiness, and light requirements of the plants should be considered. Site conditions including soil reaction, drainage patterns, and exposure should also play a role in plant selection.

The first cultural consideration is plant hardiness. Illinois has two basic hardiness zones, 5 and 6, as determined by the USDA Plant Hardiness Map. The dividing line between these two zones runs east-west from mid-Vermilion County to the northern boundary of Adams County. Exposure plays a role in the survival of marginally hardy plants. Southwest exposures are detrimental to these types of plants. Northern exposures avoid large temperature changes between day and night, thus reducing the change of winter injury.

Light is necessary for plant growth; however, the amount of light required for growth varies with species. In other words, there are "light or sun-loving" and "shade-loving" plants. Light conditions at a site should be observed and considered when selecting plants.

Soil reaction (pH) influences the growth of landscape plants. Most plants grow best in soils that are slightly acid with a pH between 6.0 and 7.0. There are plants which do not tolerate alkaline soil conditions (above 7.0). It is imperative to select plants suited for your soil condition. Elm, hackberry, linden, and walnut prefer slightly acid soils. Flowering dogwood, black gum, sweet gum, and pin require acid soil with a pH range of 5.0-6.5.

Drainage of the planting site is an important factor that should never be overlooked. Tight clay soils and low areas usually have poor drainage which limits the number of species that will grow well on sites with these conditions. Poor drainage may not be an inherent quality of the site, but may be caused by man either through compaction from heavy traffic or the shifting of natural drainage patterns. A classic mistake is the placing of a down spout off a building into a planting bed. This creates pockets of water-logged soil.

As one can see, there are many aesthetic functional and cultural factors to consider when selecting plants. The aesthetic and functional qualities of plants can provide pleasant surroundings for man. Unless the cultural requirements of plants are met all of man's planning and labor will be lost.

Table 1. List of Ornamental Characteristics of a Group of Selected Plant Materials for Use in Illinois

	Flower	Fruit	Foliage	Bark	Form
TREES					
Acer ginnala Amur maple	Inc.[a]	Red	Red fall color	Stripped	Multi-stemmed or single trunked
Acer griseum Paper bark maple	Inc.	N.O.[b]	Brown fall color	Exfoliating	Round, open
Acer rubrum Red maple	Red	N.O.	Red fall color	Gray	Ovoid to rounded
Acer saccharum Sugar maple	N.O.	N.O.	Organe fall color	Irregular plating	Upright or oval
Amelanchier arborea Shadblow serviceberry	White	Red	Scarlet fall color	Stripped	Multi-stemmed or single trunked
Cladrastis lutea Yellowwood	White	N.O.	Yellow fall color	Smooth gray	Rounded
Crataegus phaenopyrum Washington hawthorne	White	Red	Red fall color	Thorns	Spreading and rounded
Fagus sylvatica European beech	Inc.	N.O.	Bronze fall color	Elephant hide-like	Many forms depending on cultivar
Fraxinus pennsylvanica lanceolata 'Marshall's Seedless' Marshall's Seedless Green Ash	Inc.	Fruitless	Yellow fruit color	N.O.	Rounded
Liquidambar styraciflua Sweetgum	Inc.	Round, horned balls	Red-orange-purple fall color	Corky ridges on stems	Pyramidal
Koelruetaria paniculata Golden-rain tree	Yellow	Jack-O-Lantern	Yellow fall color	N.O.	Flat topped
Nyssa sylvatica Blackgum	Inc.	Blueberries on females	Red fall color	N.O.	Pyramidal

Table 1 (continued)

	Flower	Fruit	Foliage	Bark	Form
Phellodendron amurense Amur cork tree	Inc.	Blackberries	Yellow fall color	Thick and corky	Rounded
Quercus relb Red oak	Inc.	Acorn	Red fall color	N.O.	Rounded
Syringa amurense japonica	White	Inc.	Lilac-like	Cherry-like	Open
Tilia cordata	Inc.	N.O.	Dense dark-green summer foliage	N.O.	Densely pyramidal
SHRUBS					
Aesculus parviflora Bottle-brush buckeye	White	N.O.	Large dark green	N.O.	
Aronia arbutifolia 'brilliantissima' Brilliant red chokeberry	White	Bright red berries	Red fall color	Red twigs	
Chaenomeles lagenaria Flowering quince	Red-Pink	Green apple-like	Dark green	Thorns	
Clethra alnifolia Summersweet clethra	White	Persistent capsules in winter	Yellow fall color	N.O.	
Cornus alba sibirica Siberian dogwood	White	White berries	Red fall color	Bright red twigs	
Cotoneaster apiculata	Pink	Red	Deep red fall color	N.O.	
Euonymous alatus 'compactus' Compact winged euonymous	N.O.	N.O.	Scarlet fall color	Winged stems	
Ilex verticillata Winterberry holly	N.O.	Bright red	Dark green	Gray	
Myrica pennsylvanica Bayberry	N.O.	Gray berries	Dull green semi-evergreen	N.O.	

Table 1 (continued)

	Flower	Fruit	Foliage	Bark	Form
Rhus typhina lacinata Cutleaf staghorn sumac	N.O.	Red	Red fall color	Hairy stems	
Spirea prunifolia plena Bridalwreath spirea	White	N.O.	Red fall color	N.O.	
Vaccinium corymbosum Highbush blueberry	White	Blue berries	Red fall color	Green twigs	
Viburnum burkwoodi Burkwood viburnum	Pink-white	Red-black berries	Semi-evergreen	N.O.	
Viburnum carlesi Korean spice viburnum	Pink-white	Black berries	Red fall color	N.O.	

[a]Inconspicuous.
[b]Not ornamental.

Table 2. General Symptoms and Indicator Plants for Diagnosing Air Pollution Injury

Pollutant	Symptoms	Some sensitive indicator plants
Ozone	Reddish-brown stipple or bleached flecking on upper surface of the leaf; small areas merge to form irregular blotches and marginal rolling and scorch when severe. Conifers show tip burn or yellow to brown banding of the needles.	lilac, white, and scotch pine, black locust, sycamore, green and white ash, tulip poplar, European larch, aster, salvia, and dahlia
PAN (Peroxyacetylnitrate)	Collapse of tissue on lower leaf surface, which appears silver or bronze either in bands or blotches. Chlorosis or bleaching in conifers.	petunias, salvia, chrysanthemum, snapdragon, aster, and primrose
Sulfur dioxide	Light blotches occurring between veins and on the leaf margin; adjacent tissues chlorotic. Conifers show brown necrotic tips of the needles.	larch, white pine, Douglas-fir, spruce, white fir, certain crab-apples, scarlet hawthorn, violet, begonia, zinnia, verbena, and certain tulip cultivars
Fluorides	Tips and margins of leaves become necrotic with scorched appearance; a distinct separation accented by a narrow dark reddish-brown or slightly chlorotic band. Conifers show brown to reddish-brown necrotic needle tips.	pine, gladiolus, and iris

Lanphear, F.O. Urban Vegetation: Values and Stresses. *HortScience* 6:332-334. 1971.

PROTECTING LANDSCAPE PLANTINGS WITHOUT COST

F.A.Giles

Proper design in the beginning can eliminate or lessen many problems with damaged trees and shrubs. Improper or poor design can be the beginning of years of frustration, extra work, and unsatisfactory appearance.

The first step in designing is to make a complete survey of the grounds, whether golf course, park, school, or other public area. Determine the condition and type of soil as an indication of how badly it will compact, drain, and respond to plant growth. Determine or locate traffic patterns and decide how best to handle them. Existing drainage should be saved and supplemented where soil and grade have been changed. Such early planning will pay dividends as long as the facility is used.

Plan turf areas to handle modern equipment. Be certain of turning radius and width of equipment. Do not forget the equipment operator and the difficulties he may encounter in maintaining a certain design.

Place trees and shrubs in beds or shrub masses where possible. Use natural areas for this type of planting. Provide a cleared and protected area at the base of lone specimens to prevent equipment damage. Use herbicides or a structure or both.

Provide for the protection of all existing features which you plan to keep. Use fences around trees during construction--not just around the base, but the entire drip line. Bridge-over root areas and protect root systems that are to be lowered below grade. These steps and many more are described in Circular 1061, "Tree Damage Around Construction Sites."

If the facility is well established, it would be practical to analyze the existing problems and to change those that are self-inflicted. The best way to do this is to bring in an outside observer to analyze your situation. When we become used to a situation or problem, it is often overlooked.

To repeat, know the site; make good working drawings or plans; know the equipment to be used; safeguard and improve existing drainage; and save as many natural features as possible.

Proper construction of landscape features can be of great assistance in saving plants and reducing maintenance and replacement costs. Edge all beds with good serviceable materials properly installed. Freezing and thawing destroy edging, so stake it at an angle and below the frost line. Make sure the steel fits the contour of the land before it is staked. Grade changes should be done with properly constructed walls that are edged at top and bottom for easy mowing. Existing trees must be protected on sites where the grade is to be changed. This procedure is described in Circular 1061, "Tree Damage Around Construction Sites."

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Proper planting cuts plant losses and increases the length of plant life. Plants will react unfavorably for years if they are improperly planted and cared for during their establishment period.

Plant in well-prepared, well-drained planting pits. Make sure all air pockets are eliminated from the backfill soil. Plant at the proper depth, and mulch and water as long as the plant and ground are not frozen. Be sure that surface water is removed quickly and not allowed to puddle, especially during the dormant season. When planting container stock, always remove the container--no matter what it is made of--and straighten root systems to prevent girdling roots. Where the plants have become root bound, the roots will need to be cut and pulled apart. If plastic cover is to be used to cover the soil in bed areas, it should be layed to provide drainage underneath the plastic. Make sure large enough holes are allowed for plants to provide good air and moisture exchange.

Selecting plants that are adapted to a particular area, the intended use, and the soil can do much to prevent plant loss, slow growing, and unattractive plants. Extreme conditions such as wet, compacted soil always present problems. There are trees and shrubs recommended for these particular locations. The following list should be helpful in wet areas.

Trees

Acer rubrum	Red Maple
Acer saccharinum	Silver Maple
Alnus species	Alder
Amelanchier species	Serviceberry
Betula nigra	River Birch
Gleditsia species	Honeylocust
Larix decidua	European Larch
Liquidambar styraciflua	American Sweetgum
Magnolia virginiana	Sweetbay Magnolia
Nyssa sylvatica	Black Tupelo
Platanus acerifolia	London Planetree
Poplar species	Poplar
Quercus bicolor	Swamp White Oak
Salix species	Willow
Taxodium distichum	Common Bald Cypress

Shrubs

Aesculus parviflora	Bottlebrush Buckeye
Aronia species	Chokeberry
Cornus amomum	Silky Dogwood
Cornus sanguinea	Bloodtwig Dogwood
Cornus stolonifera	Red Osier Dogwood
Ilex glabra	Inkberry
Ligustrum vulgare	European Privet
Lindera benzoin	Spicebush
Myrica pensylvanica	Northern Bayberry
Vaccinium corymbosum	Highbush Blueberry
Viburnum dentatum	Arrowwood Viburnum
Viburnum lentago	Nannyberry Viburnum
Viburnum opulus	European Cranberrybush Viburnum
Viburnum trilobum	American Cranberrybush Viburnum

In areas where compaction is added to water problems, verticillium wilt is likely to be encountered. If such a problem is suspected now or in the future on the site, use plants on the following list.

Trees

Amelanchier sp.	Serviceberry
Asimina triloba	Paw Paw
Betula sp.	Birch
Carya illinoensis	Pecan
Celtis sp.	Hackberry
Crataegus sp.	Hawthorn
Eucommia ulmoides	Hardy Rubber Tree
Ginkgo biloba	Ginkgo
Gleclitsia	Honey Locust
Juniperus sp.	Juniper
Larix decidua	Larch
Liquidambar	Sweet Gum
Ostrya virginiana	Hop. Hornbeam
Platanus sp.	Sycamore
Populus sp.	Popular
Salix sp.	Willow
Taxodium distichum	Bald Cypress
Zelkova sp.	Zelkova

Shrubs

Ilex sp.	Holly
Juniperus sp.	Juniper
Pinus mugo	Pine
Salix sp.	Willow

NEW FLOWERING ANNUALS FOR LANDSCAPE USE

G.M.Fosler

Many new varieties of seed-grown flowering annuals reach the market each year--some of them representing valuable new offerings, while others are novelties of minor importance. It is my intent to call attention to 1975 and other recent introductions that have considerable landscape value.

At this time of year, it may be difficult to concentrate on next summer's outdoor plantings. Nevertheless, it's none too early to be doing your homework. This includes planning flower beds (and container plantings), buying seed, contracting for plants, ordering supplies, etc.

Ideally, you should have made your choices of varieties already last summer, retaining the best of the standard offerings on your list and adding a few new items that looked unusually good.

There are many ways to approach the task of choosing varieties for your own purposes. Maybe you use seed catalog descriptions as a guide, or take suggestions from salesmen who call on you. Even better would be to seek the professional advice of your plant supplier, local greenhouse operator, or garden center manager. Have you ever thought of conducting limited trials of your own? You can certainly find many ideas, both on varieties that perform well in your area and on pleasing combinations, from plantings you see as you travel around.

Perhaps the best idea of all is to visit one or more trialing centers several times during the season--to see the full spectrum of what's available, to evaluate performance, to note heights and spreads, and to check on freedom from disease and insects.

One of the most comprehensive plantings of its kind is the Trial Garden of Annuals and Bedding Plants maintained by the Department of Horticulture on the campus of the University of Illinois at Urbana. Its location is at the intersection of Lincoln and Florida avenues. Nearly 1,500 varieties are grown in the 1 1/2-acre plot, each fully labeled.

An important segment of the Trial Garden is the "All-America Selections" (AAS) trialing area. The U. of I. is one of 32 participants in the AAS program, the only recognized evaluation system for newly developed seed-grown flower varieties in North America. The AAS award-winning varieties for 1975 are: F_1 Carnation *Juliet* (Bronze Medal); Dahlia *Redskin* (Bronze Medal); and F_1 Pansy *Imperial Blue* (Bronze Medal).

Extensive trial gardens are also maintained by Geo. J. Ball, Inc., West Chicago, Ill.; the Boerner Botanical Gardens, Hales Corners, Wis.; and the Earl E. May Seed and Nursery Co., Shenandoah, Iowa. But other impressive plantings of annuals can be found at such places as the Chicago Botanic Garden, Glencoe, Ill.; parks

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maintained by the Chicago Park District; McCormick Gardens, Winfield, Ill.; the St. Louis Botanic Garden; etc. Don't overlook public park plantings in your own area, as well as beds in downtown malls and shopping centers, around public buildings, and in industrial complexes. These are excellent places to gleen ideas on types and varieties to use, effective combinations, adaptation to sun and shade, etc.

AGERATUM *(A. houstonianum)* (for sun) -- F_1 hybrids are available and highly recommended over older inbred strains. The new F_1 variety *Blue Angel* tops our list, but F_1 *Blue Heaven* is also a fine choice. Other good standard F_1 offerings: *Blue Blazer, Royal Blazer, North Sea,* and *Summer Snow.*

BEGONIA *(B. semperflorens)* (for shade) -- Wax begonias are rapidly growing in importance and can be counted on for garden color over a long season when grown in light to moderate shade. F_1 hybrids are preferred in this climate. There are many excellent standard varieties to choose from. For extra large flowers, try the new F_1 *Danica* and F_1 *Fortuna* series.

BROWALLIA *(B. speciosa major)* (for shade) -- This annual deserves more attention, both for beds and containers. New varieties include light-blue *Sky Bells* and deep-shaded *Ultra Blue.* Standard and good are *Blue Bells Improved* and *Silver Bells.*

CELOSIA *(C. argentea plumosa)* (for sun) -- The plumed celosias are truly excellent landscape subjects in Illinois. In the medium height class, new *Red Fox* is a good choice. Others worthy of your appraisal, in several height groups, include the *Feather* varieties, *Fairy Fountains, Crusader, Golden Torch, Forest Fire Improved,* and *Golden Triumph.*

CLEOME *(C. spinosa)* (for sun) -- Where a tall-growing annual is needed, the Spiderflower is unexcelled. Variety *Rose Queen,* rather new in the trade, is the top choice. For white flowers, choose *Helen Campbell.*

COLEUS *(C. blumei)* (for shade) -- Most seed-grown Coleus varieties should be planted in light to moderate shade; here they attain their full glory, without being faded or burned by summer sun. There are dozens of fine varieties to select from, including the well-known *Rainbow* series. One of the most recent introductions is the *Carefree* series, available in nine separate colors and a mixture. These have a dwarf bushy growth habit, and rather small, finely cut leaves.

DIANTHUS *(D. chinensis)* (for sun) -- The China pinks have received much attention from the plant breeders recently, and deservedly so, for they are colorful and highly useful for bedding purposes. Some of the more important recent introductions are F_1 *Magic Charms* (mixture and five separate colors), F_1 *Snowflake,* and F_1 *Queen of Hearts.*

GERANIUM *(Pelargonium hortorum)* (for sun) -- Geraniums from seed are an important new development in the bedding plant world. There is no question that they perform excellently in outdoor plantings, usually outdistancing standard vegetatively propagated varieties. About equal in quality are the F_1 *Carefree* (13 separate colors) and F_1 *New Era* (10 colors) series. For somewhat more of a dwarf growth habit, choose F_1 *Sprinter.*

HIBISCUS *(H. moscheutos)* (for sun) -- This subject is a hardy perennial, but since it blooms reliably and profusely the first year from seed, it is often put into the "annual" category. F_1 *Southern Belle,* a color blend introduced in 1971, is a robust grower and a fine choice with flamboyant flowers up to 10 inches in diameter. In 1975 five separate color selections are also being offered.

IMPATIENS *(I. wallerana)* (for shade) -- Here is a shade-loving bedding annual that is literally skyrocketing in popularity at present. New for 1975 are the F_1 *Grande Mixture* (a large-flowered dwarf) and *Tangeglow* (an unusual orange-flowered form). Many varieties with variegated flower coloration have been introduced in recent years, including F_1 *Scarlet Ripple,* F_1 *Zig-Zag Mixture,* F_1 *Stars and Stripes,* etc. Standard and good are such F_1 strains as the *Elfin* series, *Imp* series, *Minette* series, and the *Shade Glow* series.

MARIGOLD *(T. patula and erecta)* (for sun) -- The dwarf French marigolds are now experiencing renewed importance, and well they deserve it. Among the very best performers in our climate are the F_1 hybrid "mule-type" marigolds, including such recent introductions as *Showboat, Red 7-Star,* and the *Nugget* series. For unusually large flowers, try F_1 *Mariner,* new in 1975. Other fine recent introductions: the *Aztec* series, *Honey Moon* and *Harvest Moon, Honeycomb* and *Stardust, Pumpkin Crush,* and *Cinnebar.* Among the Tall American Marigolds, you would do well to consider F_1 *Gold Galore* and F_1 *Happy Face.* But other good less recent introductions are the F_1 *Jubilee* and F_1 *Lady* series.

NICOTIANA *(N. alata grandiflora)* (for sun) -- Another excellent but often-overlooked hot-weather annual is the Flowering Tobacco. New for 1975 are the vigorous, medium-height F_1 hybrids *Nicki-Pink* and *Nicki-White.* Reliable standard varieties are *Crimson Bedder, White Bedder,* and dwarf *Idol.*

NIEREMBERGIA *(N. caerulea)* (for sun) -- The little-known Dwarf Cupflower never fails to put on a good show. Variety *Regal Robe* is new and highly recommended, but also good are *Purple Robe* and *Purple Robe Improved.*

PANSY *(Viola wittrockiana)* (for shade) -- Pansies are excellent for spring color, but will continue blooming on through the season, particularly if F_1 hybrids are used and partial shade provided. Some of the newest offerings are F_1 *Imperial Blue* and the F_1 *Paramount* series (mixture and 10 separate colors).

PETUNIA *(P. hybrida)* (for sun) -- Petunias rank, unquestionably, as our most dependable, popular, and versatile bedding annual. Best for bedding are the F_1 Grandiflora singles and F_1 Multiflora singles, the latter being superior for mass color. Fine new varieties for 1975 include these F_1 Grandifloras: *Blue Cloud, Blue Skies, Champagne, Ricochet,* and *Viva.* But there are several hundred other fine choices on the market.

PORTULACA *(P. grandiflora)* (for sun) -- The old familiar Rose Moss has undergone considerable improvement recently and now is more dependable than ever. Top choice would be the F_1 *Sunglo* series, but the new *Sunnyside* series is also recommended.

RUDBECKIA *(R. herta gloriosa)* (for sun) -- The so-called Gloriosa Daisies are highly reliable first-year blooming perennials for this area. Rather new in the catalogs is variety *Marmalade,* more dwarf than the others and highly useful as a bedding annual.

SALVIA *(S. splendens)* (for sun) -- The Red Salvias are showy, useful, and a standard item to rely on for masses of showy color. While *Red Pillar* (Hot Jazz) remains hard to beat, you should carefully size up the following newcomers: *Red Hussar, Red Devil, Red Head, Red Baron,* and F_1 *Torch.*

SNAPDRAGON *(Antirrhinum majus)* (for sun) -- Snapdragons have limitations as a bedding plant, yet some of the newer dwarf and medium-height varieties have considerable merit for this purpose. Among the many fine standard varieties, the medium-height F_1 *Coronette* series is a rather recent introduction. For top choices in the peloric or open-faced class, you can't go wrong with any of these: F_1 dwarf *Sweetheart* series, F_1 *Little Darling*, F_1 *Madame Butterfly*, and F_1 *Orange Pixie*.

VINCA *(Catharanthus rosea)* (for sun) -- It's hard to beat the Madagascar Periwinkle as a hot-weather annual. The limelight falls on the so-called *Little* series which has largely surplanted the older, taller growing varieties. Most popular of all is dwarf *Little Bright Eye*.

ZINNIA *(Z. elegans)* (for sun) -- Everyone knows that Zinnias rank high up in the top-ten list of annuals. But their most serious defect is susceptibility to mildew and Alternaria leaf blight. There are literally scores of good varieties in a number of types to choose from, ranging in height from 6 inches to over 3 feet. Finest of the recent introductions have been the F_1 *Peter Pans*--medium-height, large-flowered varieties that amaze you with their free-flowering habit and low, uniform mounds that are ideal for bedding purposes. Varieties in this class introduced to date are: F_1 *Peter Pan Plum, Pink, Orange, Scarlet,* and a *mixture*. Another new variety, this one in the Pumila class, is the top-rated F_1 *Scarlet Ruffles*.

The above-mentioned varieties represent only a small portion of the list of recent bedding plant introductions. You are cordially invited to visit the U. of I. Trial Garden of Annuals and Bedding Plants in 1975 to size up new and standard offerings for your particular purposes. While at the Garden, you'll also have an opportunity to view many pre-introduction items, straight from the major hybridizers of the world, that promise to be on the market in the future.

For concise information on how to grow flowering annuals, we suggest that you pick up a copy of Circular 930, Flowering Annuals for Sun and Shade, from your County Extension Office.

SOIL PHYSICAL FACTORS AFFECTING TURF: WATER RELATIONS

L. Art Spomer

Water is probably the most important nutrient required for turfgrass growth and survival. Turfgrass plants contain and use more water than any other nutrient. Even though these plants appear solid and almost woody, over 90 percent of their weight is water and only 10 percent is the solid material which we see and feel. A heavy cardboard container, such as a mailing tube, filled with water also contains about 90 percent water and only 10 percent cardboard; turfgrass plants are therefore literally living, growing containers of water. Actually billions of microscopic "cardboard" (cellulose) containers are cemented together to form a plant. Plants not only contain large amounts of water, they often require hundreds of times this amount during growth. This tremendous amount of water required by plants is more than just an inert filler; water is an essential part of the living plant system and probably directly or indirectly influences every aspect of growth. Since water is so important for turfgrass growth and survival, a lack of water (water deficit, water stress) will reduce growth and may even injure or kill the plants.

All water used by turfgrass plants is absorbed from the soil which functions as a reservoir storing water (and minerals) for plant use. Since water is essential for plant growth and since the soil is the only source of water, any factor which affects the availability of soil water also affects turfgrass growth. Many plant and soil factors directly and indirectly affect plant water absorption by affecting either the availability of the soil water or the growth and permeability of the root system. This paper briefly considers the soil physical factors affecting turfgrass water absorption.

THE PHYSICAL CHARACTER OF SOIL

In a physical sense, all soils consist of three distinct parts or phases: (1) a *solid phase,* or *soil matrix,* consisting of mineral and organic particles; (2) a *liquid phase,* or *soil moisture,* consisting of water and dissolved substances; and (3) a *gas phase,* or *soil air,* consisting of the same gases as found in the atmosphere. The interrelationship among these three phases determines the overall physical character of the soil.

The *soil matrix* is the framework or backbone of the soil and dominates the soil's physical character. The soil matrix is made up of minute mineral and organic particles of various types and sizes packed into a relatively rigid, sponge-like body honeycombed with holes, or *pores* which form an interconnected network of tunnels or channels permeating the soil mass and in which water and air are held and move through the soil (Fig. 1). Since water is stored in the pores, the nature of soil pores plays an important part in determining the soil's suitability as a water storage reservoir. The nature of the pores depends upon the size and packing of the particles or on the texture and structure of the soil.

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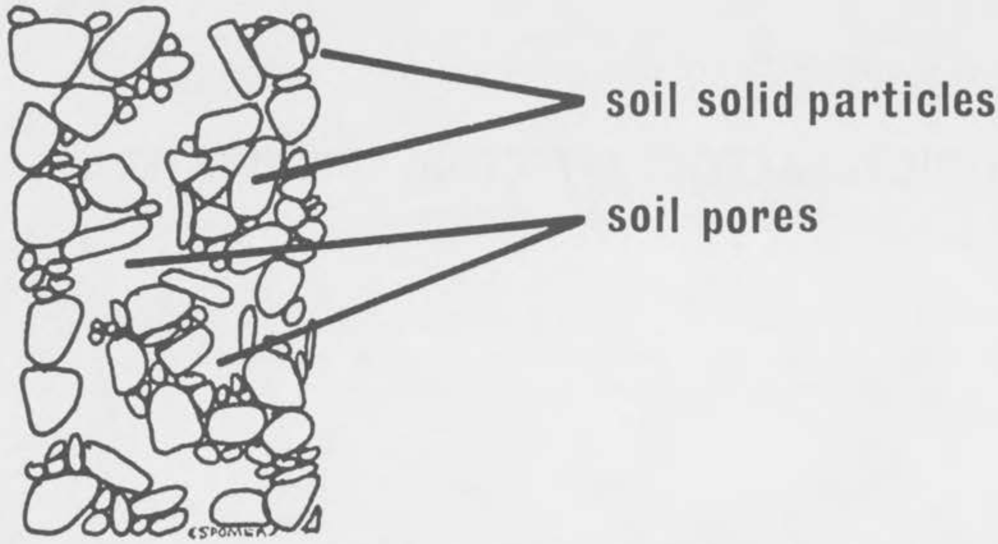

Figure 1. The soil matrix, the solid part of the soil, consists of tiny solid particles packed into a porous, semi-rigid mass. The soil water and air are stored in and move through the pore network.

Soil texture refers to the sizes of the particles that make up the soil. Most soils are mixtures of different sizes of particles and are classified according to the amount of each size they contain. Knowledge of soil texture alone is usually not sufficient to determine a soil's suitability as a water reservoir, unless the soil is pure sand, because mixtures of particles, particularly those containing colloids, tend to stick together into *aggregates*. Soil structure is the soil characteristic based on aggregation or packing arrangement (Fig. 2).

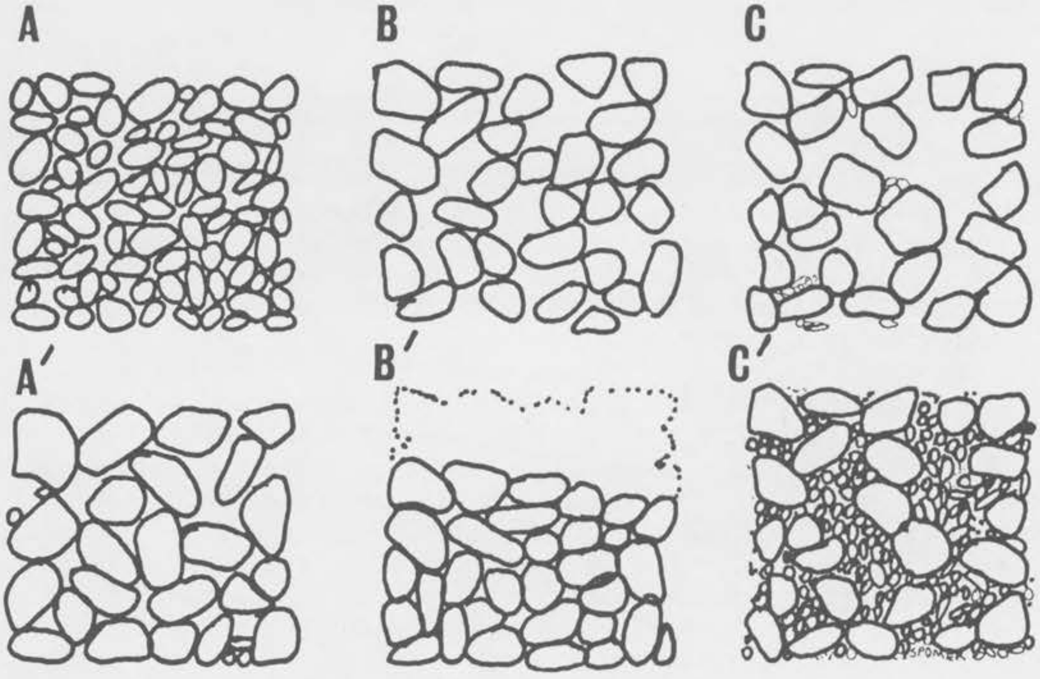

Figure 2. Soil texture (A), compaction (B), and mixture (C) all influence both the total amount and size of soil pores. Soils A, B, and C have greater total porosity than the corresponding soils A', B', and C'.

Open-structured soils have many large pores as opposed to closed-structured soils, which have few. In general, the optimum soils for turfgrass production and maintenance have a combination of both large and small pores.

Soils are also often classified as *organic* or *inorganic*, depending on the proportions of organic or mineral particles they contain. *Organic* particles are plant and animal residues in various stages of decay. *Inorganic* or mineral particles are tiny bits of bedrock material *(primary minerals)* or products of chemical alteration of bedrock material *(secondary minerals)*. Organic soil physical character differs markedly from and generally changes more readily than that of mineral soils.

The second most important factor affecting the physical character of soil is *soil moisture*, which is the water retained in the soil following irrigation, precipitation, or in some cases movement upward from a water table. It consists of a solution of water and dissolved gases and minerals that wets soil particles and fills soil pores.

When a turfgrass area is irrigated (or it rains), water fills or saturates the upper layers of soil and gradually moves or drains downward through the pores in response to gravity. Some of this water is retained near the surface and some drains completely out of the root zone (Fig. 3). The water which drains out of the root zone is called *gravitational water* and is unavailable for plant use. Some of the water is retained as the humidity in the soil air *(water vapor)*; but this is such a small amount that it is generally not a significant source of supply for turfgrass use. Another form of retained water, *hygroscopic water*, is absorbed so tightly to the particle surfaces that it is also unavailable for plant use. The main source of water for turfgrass use is the liquid water or *capillary water* which is retained in the soil following irrigation and drainage.

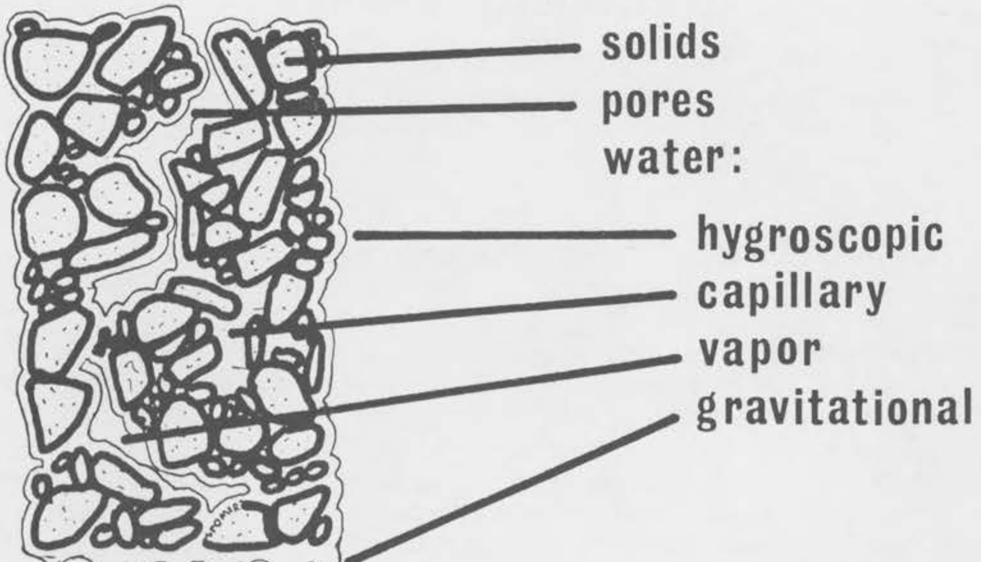

Figure 3. There are four different classes of soil moisture: capillary, hygroscopic, vapor, and drainage water. Only capillary water is a significant source of water for plant use.

In relation to plant growth, soil moisture is best described in terms of the *amount* of water retained and the *tightness* with which it is held in the soil. The amount of water is expressed as percentage of soil volume, and the tightness of retention is expressed as *soil suction, soil moisture tension,* or *soil water potential.* As water is removed from the soil, the remaining water is more tightly held and is less available for plant use. The relationship between the amount and tightness of retention is called the *soil moisture characteristic* and is probably the single most useful physical measure of a soil's suitability as a water reservoir (Fig. 4).

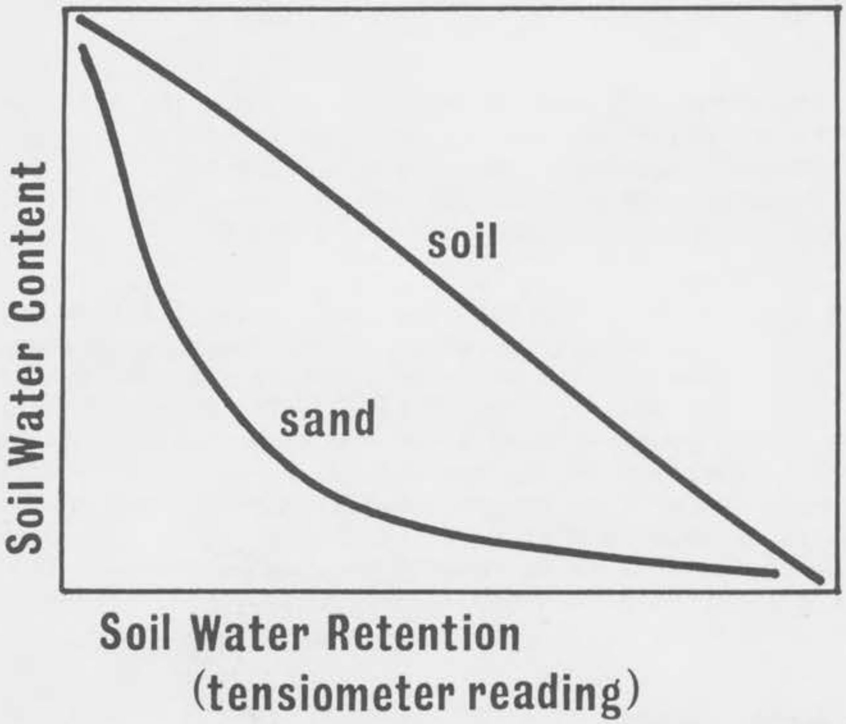

Figure 4. Soil water availability is best described by soil water retention and content. The relationship between these two factors is called the soil moisture characteristic. Availability decreases as soil water content decreases and soil water retention increases.

Soil air is the least dominant factor affecting the physical character of the soil; yet, it is still very important in determining the suitability of the soil as a water reservoir. Soil air is found in the soil pores not filled with water. Soil air contains the same gases as the atmosphere, except in different proportions (Fig. 5). Atmospheric air composition remains essentially constant; however, since plant roots and soil microorganisms utilize oxygen and produce carbon dioxide during their life processes, both soil oxygen and carbon dioxide contents vary significantly over short periods of time (soil carbon dioxide concentrations are almost always higher than atmospheric). Since oxygen is essential to maintain root growth and activity, oxygen must be continually resupplied to the soil. This resupply is carried out through the process of *soil aeration* which is the exchange of carbon dioxide and oxygen between the soil and atmosphere. Since aeration occurs mainly through open, air-filled pores, maximum aeration occurs in dry or open-structured soils that drain quickly following irrigation (Fig. 6). However, a soil with too many large pores may not hold sufficient water to be suitable as a soil reservoir.

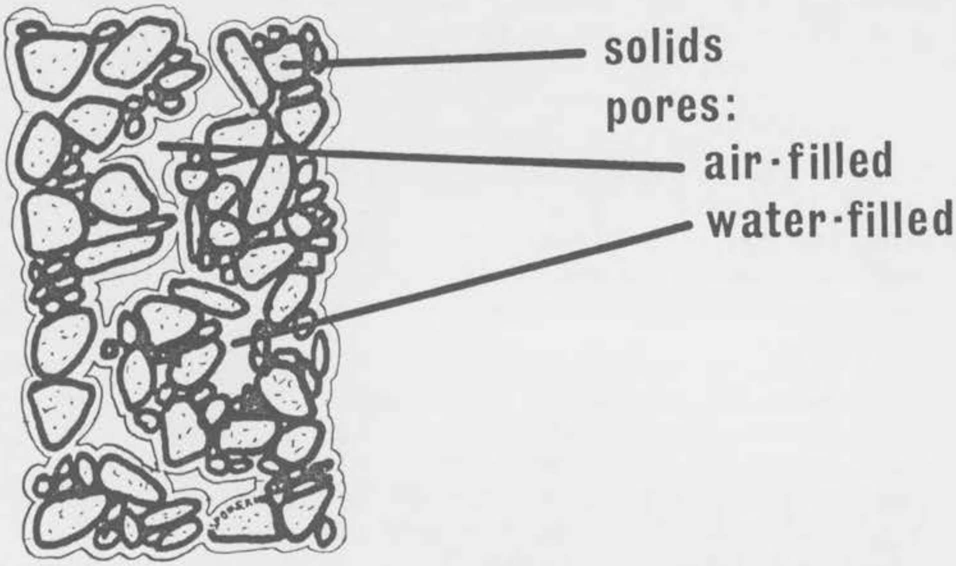

Figure 5. Soil air occupies the open or non-water-filled pores. The soil carbon dioxide concentration is usually higher and the oxygen content lower than in the above-ground air.

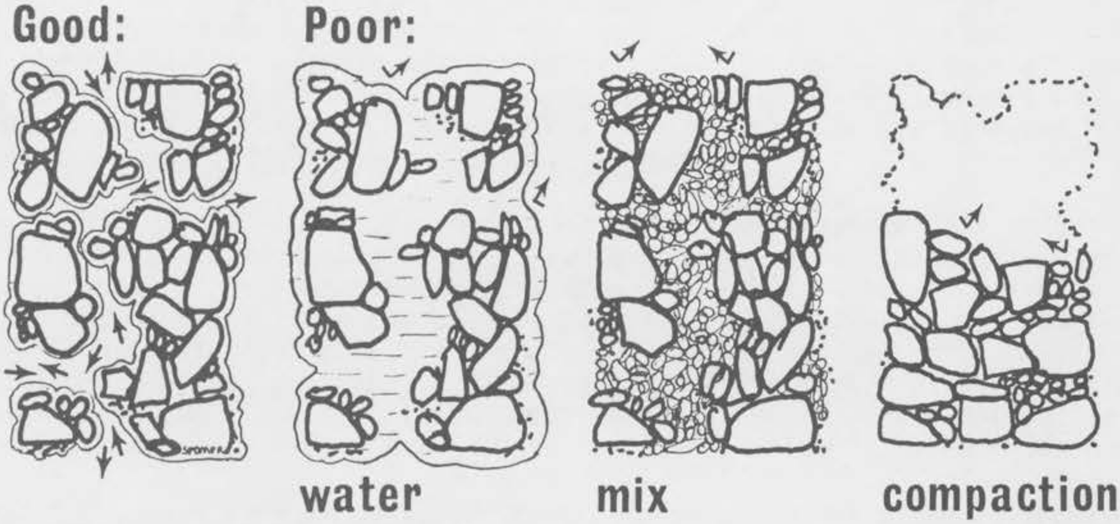

Figure 6. Soil aeration is the exchange of oxygen and carbon dioxide between the soil and above-ground atmospheres through the open soil pores. Any factor which reduces the amount of open pores will reduce soil aeration.

The interrelationship between these three soil phases determines a soil's suitability as a water storage reservoir for turfgrass. This interrelationship can be illustrated by a simple soil model. If a large glass jar represents a volume of soil, the empty jar represents 100 percent of the volume as soil air. When a dry, sieved soil is added to the jar, the solid particles fill approximately 70 percent of the volume, leaving 30 percent soil air, or *open pore space*. When water is added to the soil, it fills a portion of the pores and further reduces soil air volume. The maximum water content when the soil is *saturated* or maximum air content when the soil is completely dry is determined by total pore volume (30 percent in this example). If this soil contains 25 percent water, it has only 5 percent of its volume available for soil air. In other words, the total capacity of the soil reservoir is determined by the matrix, and the amount of air in a soil depends upon both the amount of pores and the water content.

WATER ABSORPTION BY PLANTS

Although the soil initially determines the availability of the water which it contains, the growth and permeability of the turfgrass roots are also highly important. The path of water through grass plants begins when it is absorbed from the soil by the roots and ends when it is either incorporated into the plant tissues or evaporated *(transpired)* from the leaves.

Water absorbed by the roots moves along cell walls, intercellular spaces, or directly through cells toward the center of the root. Most of the water (and minerals) used by turfgrass plants is absorbed through the *root hair zone* located just behind the growing root tip. The root hairs are hair-like extensions from the surface cells of the root. Root hairs increase the total absorbing surface of the root one to five times and also increase the effective diameter of the root several times. Water absorbed by the tip is used primarily for the growth of the root and little is translocated to the above-ground portions of the plant. The older, maturing root behind the root hair zone becomes impermeable to water. All absorbed water passes through at least one layer of living cells, *endodermis*, in its path through the root. Water movement through this layer is affected by the health or physiological activity of the root which, in turn, can be affected by a number of factors, including soil aeration, temperature, physical injury to cells, and nutrition. This absorbed water eventually enters the plant's vascular system (xylem and phloem tissues), which is a network of pipe-like cells extending to all parts of the plant. It is then rapidly distributed within the various plant tissues by moving from cell to cell along intercellular spaces or directly through cell walls.

Transpiration occurs primarily through tiny pores *(stomata)* in the leaf's surface. The rate of transpiration by grass depends on the intensity and duration of sunlight, relative humidity of the air, rate of wind movement, and various other internal and external plant characteristics. The amount of water in the plant is regulated by the balance between water absorption and transpiration. Under conditions favoring high transpiration rates (i.e., high sunlight, low relative humidity) or low absorption rates (i.e., dry soils, poor aeration), the probability of severe water deficit, wilting, reduced growth, and injury is quite high.

The movement of water through plants as just described is well known, but the actual mechanism responsible for its movement is still not completely understood. The main facts to remember are: if water is available in the soil and the grass plant roots are healthy and growing, the water is readily absorbed and distributed throughout the entire plant body.

THE SOIL WATER RESERVOIR

The suitability of the soil as a water reservoir depends on its capacity to retain water and supply it to the plant. This includes the effect of the soil environment upon root growth and permeability (aeration). Since soil air and water are mutually exclusive (as water content increases, aeration decreases), turfgrass irrigation management requires the maintenance of a balance between adequate soil water content and adequate aeration.

Maximum water content occurs in soils with many small pores that hold water against gravitational forces (drainage) following irrigation. However, a soil with too great a proportion of small pores may not provide sufficient aeration. To maintain an optimum balance between water content and aeration for turfgrass growth, one must know the physical character of the soil, practice good soil and irrigation management, and have experience with the particular grass and environmental conditions involved.

CONTROLLING SOIL PHYSICAL PROPERTIES

In practice, it is possible to control soil physical properties within certain limits. The most common form of soil physical control is achieved through soil amendment. Soil amendment is discussed in detail in another paper in this proceedings.

KENTUCKY BLUEGRASS SYMPOSIUM

HISTORY OF KENTUCKY BLUEGRASS

W.A.Meyer

ORIGIN

Kentucky bluegrass (*Poa pratensis L.*) has also been referred to as smooth-stalked meadowgrass, meadowgrass, or Junegrass. There are no records to indicate that Kentucky bluegrass was present in the United States before the 17th Century. It was most likely introduced into the United States as seed in hay from Europe during the 1600's. William Penn recorded sowing it in 1684. By the mid-1700's it was mentioned often and appeared naturally in areas where the land was drained (4).

Settlers found bluegrass and clover abundant in the meadows of Ohio, Kentucky, and Indiana, and Indians called it white man's foot grass (4). This wide distribution over such a large geographic area in a 100-year period has been used by some to support the theory that Kentucky bluegrass may have been a native to the United States. A tour through the mountainous regions of Colorado certainly illustrates the wide distribution of this species at many different altitudes and on many types of terrain.

USES

Today Kentucky bluegrass is the major turfgrass used throughout the temperate region of the United States. It is a long-lived perennial in the cool, humid regions and transitional zones and can also be grown in the arid and semi-arid regions if it is irrigated. Kentucky bluegrasses are widely used on home lawns, parks, cemeteries, golf courses, and athletic fields in the temperate zones (1,4).

TURF QUALITIES

The extensive rhizomes of Kentucky bluegrass give this species some unique qualities that other turfgrass species lack. These rhizomes give this species excellent sod-forming qualities and good recuperative potential. They also allow Kentucky bluegrasses to spread laterally which reduces the seed quantities needed for establishment. Kentucky bluegrass is also capable of surviving drouth periods by means of underground rhizomes which can produce new tillers when moisture conditions become favorable.

Most Kentucky bluegrasses also have good cold tolerance, color retention, and tolerance to most commonly used turf herbicides. They have medium wear tolerance and are relatively easy to maintain compared to most other turfgrass species. Since most varieties of Kentucky bluegrass possess the apomictic (asexual) method of seed production, the good qualities of the parent plant are maintained in each seed generation. All of the above qualities have contributed to establishment of Kentucky bluegrasses as the predominant species grown in the temperate zone.

EARLY SEED SOURCES

Kentucky bluegrass seed was first harvested from wild stands in Kentucky, then later in Missouri and other midwestern states (4). This seed was referred to as

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Common Kentucky bluegrass seed. Many of the parks and golf courses established throughout the midwest during the early 1900's were seeded with this Common Kentucky bluegrass seed.

The varieties Geary and Delta were single-clone selections released in 1929 and 1938 respectively. Both of these selections were susceptible to *Helminthosporium* leaf spot, which was also the important disease associated with turf established with Common Kentucky bluegrass seed (1,3).

DEVELOPMENT OF MERION

The release of the leaf-spot-resistant variety Merion in 1947 had a tremendous impact on the turf industry in the U.S. The development of this low-growing turf-type bluegrass indicated what selection work could do to improve this species. The development of Merion also encouraged the production of turfgrass seed in the northwest where other native bluegrasses would not contaminate seed lots (4). The rapid development of the sod industry in the United States during the 50's and 60's was strongly affected by the appearance of Merion because of its leaf spot resistance and excellent sod-forming qualities.

As Merion was grown more widely during the 1950's and early 1960's certain weaknesses of Merion were recognized. Powdery mildew, rust, stripe smut, and *Fusarium* blight were identified as serious diseases affecting Merion.

The variety Park, consisting of 15 strains, was released in 1957 and reported to have better seedling and turf vigor than Merion and to be more rust resistant. Newport was a single-clone selection released in 1958 because of stem rust and powdery mildew resistance and good seedling vigor. Prato and New Dwarf were additional new varieties which were similar to Park and Newport because of their susceptibility to leaf spot. This susceptibility to leaf spot limited the usage of these varieties in comparison to Merion and is a strong indication as to the importance of this disease. The varieties Prato and Newport were also susceptible to stripe smut (1,3,4).

Newport is a variety which has been grown quite widely, in spite of its susceptibility to disease, because of high seed production. Since it is a high seed yielder it was grown in the northwest as a single cultivar, but sold on the seed market as Common Kentucky bluegrass (4).

The varieties Kenblue and South Dakota Certified were released and certified to represent good sources of truly common Kentucky bluegrass which consisted of many wild types naturally found in Kentucky and South Dakota. These two varieties are similar to the original Common Kentucky bluegrass in their susceptibility to leaf spot (1,3).

IMPROVED VARIETIES OF THE 1960's

The varieties A-34, A-20, Nugget, Pennstar, Sodco, Fylking, and Sydsport are all varieties released during the middle to late sixties which were improvements over Merion because of their resistance to both leaf spot and stripe smut. These varieties are also more resistant to powdery mildew, and in varying degrees possess better rust resistance than Merion. Unfortunately, varieties such as Nugget have poor winter color and spring green up, with more susceptibility to dollar spot disease than Merion. Some of these new varieties are also more susceptible to *Fusarium* blight than Merion. Some varieties such as Nugget and A-34 have better shade tolerance than most other varieties (1,5).

IMPROVED VARIETIES OF THE EARLY 1970's

Other new varieties have been released in the last four years which have qualities similar to the group released during the middle to late 60's. Some of the more prominent varieties are Adelphi, Bonnieblue, Victa, Glade, Brunswick, and Baron. Adelphi, Bonnieblue, and Brunswick are reported to have good resistance to leaf spot and stripe smut. Adelphi is also well known for its deep blue color. Glade is reported to have good resistance to powdery mildew and stripe smut. Baron and Victa are both excellent seed yielders with above-average disease resistance (2).

FUTURE CONSIDERATIONS

From the previous historical discussion it is obvious that certain diseases and the lack of good turf qualities have been the limiting factors in the production of Kentucky bluegrass turf. There is still a great need to develop new varieties in the future which have better shade tolerance, low cutting tolerance, low fertility requirements, and broad-based disease resistance.

REFERENCES

1. Beard, J.B. Turfgrass Science and Culture. Prentice Hall. 658 p. 1973.

2. Funk, C. Reed. Personal communications. 1974.

3. Hanson, A.A., F.V. Juska, and G.W. Burton. Species and Varieties. p. 370-409. In Turfgrass Science, American Society of Agronomy, No. 14. 1969.

4. Madison, J.H. Practical Turfgrass Management. Van Nostrand-Reinhold Co. 466 p. 1970.

5. Turgeon, A.J., and W.A. Meyer. Effects of Mowing Height and Fertilization Level on Disease Incidence in Five Kentucky Bluegrasses. Plant Disease Reporter 58:514-516. 1974.

IMPROVING KENTUCKY BLUEGRASS FOR TURF

C. Reed Funk

Kentucky bluegrass(*Poa pratensis L.*)is the leading lawn type of turfgrass in the northern half of the United States. It is hardy, attractive, and widely adapted. This development and use of improved varieties will make this species of even greater usefulness.

The most important attributes of an improved bluegrass variety are dependability, durability, reduced maintenance requirements, and attractive appearance. Each of these attributes can be improved as we add improved resistance to diseases, insects, nematodes, and weeds, a lower growth habit and better turf-forming properties, and increased tolerance of various environmental stresses such as heat and drought. Adaptation to specialized uses and environments are also important. Bluegrass varieties with improved tolerance of shade, close-mowing, excessive wear, and poor soil conditions would greatly enhance the value of the species. Varieties of unique or striking color and appearance would be very useful for diversification in special landscape patterns and effects.

PEST RESISTANCE

Plant breeding often makes its greatest contribution in the development of varieties with improved genetic resistance to major disease, insect, and nematode problems. Present and prospective restrictions on the use of pesticides make genetic resistance of even greater significance. Varieties undamaged by disease and insects are more resistant to weed invasion and more tolerant of heavy use. A few years ago, Merion was the only Kentucky bluegrass variety with good resistance to the leafspot and crown rot disease incited by *Helminthosporium vagans*. At present a substantial number of other bluegrass varieties with good resistance to this disease are also available. Many of these newer varieties also have the added advantage of genetic resistance to the stripe smut disease. Programs to develop resistance to powdery mildew, dollarspot, and the various rusts are producing varieties resistant to many of the present races of these diseases.

However, it appears that the development of new races may often make the resistance of these varieties of a temporary nature unless broadly based, non-race-specific types of genetic resistance and tolerance are used. The skillful blending and mixing of resistant varieties and species may prove helpful in providing the genetic diversity needed for the more permanent type of resistance needed in a perennial turf. Considerably greater effort should be directed toward controlling the Fusarium blight disease through the development of greater genetic resistance. Extensive programs in progress at Warren's Turf Nursery, O.M. Scott's and other research stations will be followed with interest as they attempt to develop varieties with greater resistance to this disease.

There has been very little effort expended to improve the insect resistance of Kentucky bluegrass. Nevertheless, observations indicate that substantial progress

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might be made. Scientists at the University of Kentucky report considerable variation in the amount of sod webworm injury found in different selections of Kentucky bluegrass. Alexander Radko of the USGA Greens Section has observed bluegrasses with apparently good resistance to chinchbug attack. Considerable variation has been noted in aphid damage received by various Kentucky bluegrass varieties in nursery plantings in New Jersey. Dr. Jerry Pepin observed that Brunswick Kentucky bluegrass showed little damage from a grasshopper attack in his Indiana nursery.

HERBICIDE TOLERANCE

Seed growers have observed substantial variation in the sensitivity of different bluegrass varieties to the phytotoxic effects of various herbicides. Studies at Rutgers show marked differences in the tolerance of Kentucky bluegrass varieties to tricalcium arsenate. The development of turfgrass varieties with specific resistance to highly effective herbicides would permit much more selective control of present weed problems. Certain Zoysia varieties are highly tolerant of atrazine and simazine. Others are rather sensitive. This difference appears to result from a single gene difference. Such tolerance permits the use of these highly effective herbicides in the selective control of many weeds troublesome in the establishment and maintenance of Zoysia. Would it be possible to breed a Kentucky bluegrass variety highly tolerant of a chemical and which could be used to selectively remove annual bluegrass, bentgrass, or tall fescue? Research in this field should be expanded.

SHADE TOLERANCE

The combination of trees, ornamental shrubs, and turf in lawns, parks, and recreational areas adds greatly to the beauty and enjoyment of our outdoor environment. The development and use of turfgrass varieties better adapted to such shaded locations should be of great benefit. The successful performance of the Nugget and Warren's A-34 varieties of Kentucky bluegrass in many situations involving moderate shade demonstrates that Kentucky bluegrasses with improved shade tolerance can be developed. Such shade-tolerant varieties must have good resistance to leaf spot, powdery mildew, and other diseases which are particularly damaging under moist, shaded locations having reduced air circulation. They must also have the ability to limit vertical leaf elongation and thereby divert the food produced by photosynthesis to tillering, root and rhizome production, and carbohydrate storage.

The ability of some of the fine fescue varieties to tolerate poor, acid, infertile soil conditions frequently associated with many shaded locations undoubtedly contributes to their success as a shade-tolerant component of a mixture. A shaded location in New Jersey was seeded to a mixture of the more shade-tolerant fine fescue and Kentucky bluegrass selections. The fine fescues are dominating in areas where tree root competition is most severe. The shade-tolerant bluegrasses are dominating in equally shaded areas where tree root competition is less of a problem.

TURF-TYPE GROWTH HABIT

The fineleaf, dwarf-type bermudagrasses developed by Dr. Glenn Burton and others illustrate the profound changes that can be made in the growth habit of a species. The growth habit of Kentucky bluegrass is greatly modified by daylength, light intensity, and temperature. During short days bluegrass assumes a more decumbent growth habit, rate of leaf elongation is reduced, and abundant tillering occurs.

During long days, growth is more erect and leaf elongation is more rapid. Reproductive development also occurs during the long days of late spring.

Common Kentucky bluegrass and varieties such as Park, Delta, and Kenblue have a rather erect growth habit with a rapid rate of vertical leaf elongation. Such varieties will not tolerate high nitrogen fertility and close mowing, especially during the spring and summer seasons. During the long days of spring and summer these varieties divert most of their growth upward. Leaf area is mowed off so frequently that a good, dense turf is difficult to attain. Carbohydrate food reserves are depleted and such varieties become highly susceptible to damage from the Helminthosporium leaf spot and crown rot disease.

Varieties such as Glade and Nugget appear to exhibit the short day-length response of decumbent growth and slow leaf elongation through much more of the year than the common type of bluegrass varieties. Increased understanding of the differential varietal growth response to day length should be of great value in breeding turfgrasses with better turf-forming properties and a reduced mowing requirement. Such programs may well make increased use of germplasm collected from arctic regions where summer days become very long.

COLOR

Renewed interest in better color during late fall, winter, and early spring has been stimulated by recent research in Rhode Island, New Jersey, and Virginia on late fall and winter fertilization. This is especially evident in areas of moderately mild winter temperatures and where turf receives some protection from cold, drying winds. Kentucky bluegrass varieties differ greatly in their ability to maintain good winter color. Kentucky bluegrass varieties such as Adelphi, Bonnieblue, Majestic, and Georgetown are outstanding in their ability to retain excellent color into the winter and to green-up early in the spring.

Practically any shade of green color can be observed in an experimental turfgrass planting. Types like Brunswick have a very attractive, bright, moderately light-green color. Varieties of this nature should be very useful in situations where contamination with annual bluegrass is likely to occur. Adelphi and Nugget have a bright, dark-green color. It should be possible to develop bluegrass varieties of about any shade of green dictated by personal preference.

TOLERANCE OF PROBLEM SOILS

Current shortages and high prices of fertilizer emphasize the need of developing and using varieties which perform well at low fertility levels. Turfgrass is grown on a wider range of soil types than any crop plant. Varieties with specific adaptation to particular problem soils can and should be developed. Recent success in hybridizing Belturf Kentucky bluegrass with Canada bluegrass (*Poa compressa L.*) selection opens new approaches to obtaining bluegrasses with better adaptation to poor soils.

BLUEGRASSES FOR THE TRANSITION ZONE

Improved tolerance of the summer heat, drouth, and disease problems of the transition zone would be of great benefit. Most of the very attractive, dense, lower-growing bluegrasses selected in the cool-summer climates of Northern Europe and from other breeding and evaluation tests located in less severe environments are disappointing in Southern trials. An extensive program to collect and evaluate adapted germplasm from summer stress areas of the transition zone should provide varieties with greatly improved summer performance and dependability. Under conditions of moderately low nitrogen fertility and high cut, narrow-leaved varieties such as Kenblue have survived well in the transition zone. Under conditions of closer mowing, the lowergrowing, widerleaved, somewhat open types with extensive deep rhizomes such as Vantage and P-154 are commonly observed to perform well in the warmer parts of the mid-Atlantic region.

APOMICTIC REPRODUCTION

Kentucky bluegrass produces seed both sexually and asexually, the latter through a process called apomixis. Apomixis is a process whereby a vegetative cell in the ovule develops into the embryo of the seed without fertilization by the male nucleus of the pollen. Seed formed by this apomictic method of reproduction is therefore genetically identical to the mother plant. Some bluegrasses, such as Merion and Glade, produce nearly all of their seed by apomixis. Such a plant will breed true and can be used as the basis for a new variety merely by increasing seed. Other bluegrasses such as Warren's A-20 are highly sexual and must be propagated vegetatively to maintain identity to the parent selection. Apomictic reproduction combines the advantages of "seed" with many of the advantages of vegetative propagation. Hybrid vigor and uniformity are characteristics of apomictic varieties. Apomictic reproduction also helps overcome many of the problems of hybrid sterility frequently found in making wide crosses.

BREEDING KENTUCKY BLUEGRASS

New varieties of Kentucky bluegrass can be developed by:

1. Selection of desirable plants from old turf areas.
2. Mutation breeding.
3. Intraspecific hybridization.
4. Interspecific hybridization.

Most of the currently available bluegrass varieties originated as individual plant selections from old turf areas where natural selection had allowed promising plants to express themselves. Observant individuals detected these outstanding plants and proceeded to evaluate them for possible use. Approximately 40 percent of the bluegrasses collected from golf courses, pastures, lawns, and other old turf areas of the northeastern United States have been sufficiently apomictic to maintain varietal identity. Such collections will continue to be a source of new varieties and germplasm for hybridization programs. Breeding firms have made extensive collections of Kentucky bluegrass from turf areas of northwest Europe. A substantial number of attractive selections have been screened from these collections and are being evaluated in the United States. As would be expected, many of these European bluegrasses are not well adapted to the severe summer stress conditions found in many areas of the United States. Some are extremely susceptible to stripe smut or the Fusarium blight disease.

Some bluegrasses collected in northwest Europe including Fylking and Baron have become successful as varieties in the United States. Other selections being tested, including Birka from Sweden and Enmundi from Holland, show considerable promise. While we can be thankful to European breeders for their contributions to our turfgrass industry, it would be unwise to depend entirely on their efforts to solve all of our variety needs. Collection programs to gather adapted germplasm from summer stress areas of the United States and regions of similar climates should be strengthened. Turf professionals working in the field can be of great assistance in making these collections.

The use of mutagenic agents to improve Kentucky bluegrass is being investigated by breeders at Ohio State, Beltsville, Maryland, and in Europe. The use of mutation breeding for the improvement of apomictic plants has many advantages. These programs will be followed with great interest.

Hybridization allows the breeder to recombine many of the best characteristics of two or more parents into one plant. Apomictic reproduction allows us to use this plant as the foundation of an improved hybrid variety. Adelphi and Bonnieblue are examples of Kentucky bluegrass varieties bred by intraspecific hybridization. Interspecific hybridization can also be used in the improvement of Kentucky bluegrass by adding valuable germplasm from other species of Poa.

KENTUCKY BLUEGRASS VARIETAL EVALUATION RESULTS

Kenyon T. Payne

Kentucky bluegrass cultivars and selections have been evaluated at five locations from northern to southern Michigan on organic, inorganic, and sandy soils, as well as on a heavily shaded test area. In general, there is a good correlation in the performance of the varieties at the several sites. The tests are established and maintained by J.B. Beard; appearance ratings have been taken by the author; J.M. Vargas has made the disease evaluations; and studies of wear tolerance, water-use rate, low-temperature hardiness, and submersion tolerance have been made by J.B. Beard and his graduate students.

Merion has been an excellent cultivar. In recent years, however, inoculum has built up for several diseases, and severe attacks of *Fusarium* blight, stripe smut, and powdery mildew (in shaded areas) have decreased its value as a lawn grass. Rust is rarely a major disease in Michigan, but increasing levels of leaf spot are being noted.

Nugget performed exceptionally well until 1974. Winter conditions resulted in a brownish purple color in the spring, and severe dollar spot infestations occurred, particularly at low fertilizer levels (2 to 3 lb. N). *Fusarium* is also a factor, although Nugget does not appear to be as susceptible as Merion, Fylking, and Pennstar. Nugget has been outstanding in dense shade trials. This cultivar and A-34 appear to be far superior to all other bluegrass cultivars tested, and have performed better than Pennlawn red fescue in this trial.

NJE P-56 has been outstanding in density and dark-green color throughout the season, and in resistance to all diseases thus far.

Adelphi, Galaxy, Baron, A-20, Sodco, Bonnie Blue, Belturf, Majestic, and A-34 have performed well and are superior to Merion, particularly because of disease resistance. Blends of these are suggested to reduce potential disease epidemics.

The following lists have been prepared by J.B. Beard to indicate grouping of varieties by reactions to several stresses.

WEAR TOLERANCE

Good	*Medium*	*Fair*
Fylking	Cougar	A-34
Nugget	Campus	Merion
Pennstar	Prato	Delta
Baron	Belturf	Kenblue
	Park	Windsor

K.T. Payne is Professor, Department of Crop and Soil Sciences, Michigan State University.

WATER SUBMERSION TOLERANCE

Excellent	*Good*	*Medium*	*Fair*	*Poor*
Belturf	A-34	Park	Merion	Pennstar
Monopoly	Windsor	Sodco	Fylking	Cougar
	Kenblue		Sydsport	Newport
	Baron		Galaxy	Prato
				Delta
				Nugget

WATER-USE RATE

Very Low	*Low*	*Medium*	*High*	*Very High*
Prato	Pennstar	Merion	A-34	Sodco
Cougar	Park	Galaxy	Newport	Sydsport
Delta	Nugget	Monopoly	Fylking	
Kenblue	Windsor	Baron		

LOW-TEMPERATURE HARDINESS

Excellent	*Good*	*Medium*	*Poor*
Nugget	A-34	Delta	Kenblue
	Merion	Prato	Campus
	Windsor	Cougar	
	Fylking	Park	
	Belturf	Newport	
	Pennstar		

SHADE ADAPTATION

Good	*Medium*	*Fair*	*Poor*	*Very Poor*
Nugget	Belturf	Fylking	Windsor	Park
A-34	Galaxy	Pennstar	Prato	Newport
	Captan	Georgetown	Kenblue	Campus
	Merion	Cougar	Monopoly	Delta

OVERALL PERFORMANCE RANKING

Excellent	*Good*	*Medium*	*Fair*	*Poor*
Nugget	Cheri (Golf)	Fylking	Captan	Park
Adelphi	Brunswick	Pennstar	Delft	Delta
Galaxy	A-34	Newport	Zwantberg	Kenblue
A-20	Merion	Georgetown	Arista	Geary
Sodco	Birka	A-10	Windsor	Troy
Majestic	Monopoly	Silverblu	Prato	Atlas
Bonnieblue	Sydsport	Primo		Shandia II
Belturf		Spath		S-21
Baron		Cougar		Minn. 6
		Campus		Nike
				Arboretum
				Palouse
				Fusa

KENTUCKY BLUEGRASS VARIETY EVALUATION
Michigan State University
1969 - 1973 (approximately 80 observations)

General appearance
1 = best 9 = poorest

Cultivar	*Rating*
NJE P56	1.5
Nugget	2.0
Adelphi	2.1
Galaxy	2.2
A-20	2.2
Sodco	2.2
Baron	2.3
Bonnie Blue	2.4
Belturf	2.4
Majestic	2.4
A-34	2.5
Merion	2.5
Cheri (golf)	2.5
Sydsport	2.7
Pennstar	3.2
Fylking	3.4
Newport	3.4
Georgetown	3.5
Windsor	4.1
Kenblue	4.4
Park	4.9
So. Dakota Certified	6.1

FIVE-YEAR OBSERVATIONS OF KENTUCKY BLUEGRASS VARIETIES IN MISSOURI

John H. Dunn

Evaluation of Kentucky bluegrass varieties began at the University of Missouri in the late 1950's and early 1960's when several common and so-called improved varieties and selections were established at the Horticulture Department's New Franklin Farm, 20 miles west of Columbia. Later in the 1960's the Missouri Valley Turf Association surveyed its members to determine what turf information was most needed from turf researchers of the Horticulture Department. Information on varietal adaptation topped the list and, in part, was responsible for our planting 54 Kentucky bluegrass varieties and selections in the fall of 1968 at Columbia, as part of a regional study involving 15 universities. The regional approach enables us to evaluate the same varieties in many different environments, but with similar plot management at each location.

Soil on which the bluegrasses were established is a silt loam with a good inherent level of fertility and an organic matter content of about 4 percent. The ample organic matter can be attributed to a native Kentucky bluegrass pasture which preceded the test plots. Plots are fertilized in September, October, late winter, and late spring of each year with a total of 3 to 4 lb. N per 1,000 sq. ft. in the form of a complete fertilizer (10-6-4, 18-5-9, or 12-4-8). We mow 1 or 2 times a week with a reel-type mower and leave the clippings. Crabgrass is controlled with an annual application of preemergence herbicide and clover. Broad-leaved weeds are removed with applications of 2, 4-D or 2, 4-D + silvex as needed. No fungicides or insecticides have ever been applied to the test area. Plots are irrigated to prevent serious drouth stress in the summer months.

During the six-year interval since 1968, the varieties have been studied for such factors as overall quality, disease tolerance, and spring and fall color. However, in Missouri we are most concerned with the appearance of Kentucky bluegrass during the months of summer stress. The following table is included to indicate overall average quality of the varieties during five summers at Columbia.

Varieties like A-20, A-34, Birka, WK-412, Fylking, Sodco, Bonnieblue, and Windsor have given us mostly good-quality turf over five summers, while at the other extreme South Dakota, Campus Arista, Delta, and Nugget are among those which have adapted poorly in our mid-Missouri turf plots. Poor quality of Nugget has been mostly caused by a high susceptibility to summer diseases, probably *Rhizoctonia* and/or *Fusarium* species. This same variety has given excellent turf in more northerly parts of the country and serves as an example of why it is beneficial to conduct regional studies for several years and to compare notes before general conclusions are drawn about the performance of a variety.

While the five-year averages are generally representative of the year-to-year quality of most varieties in this study, a few have shown a large improvement over the past two years which is not completely reflected in the average. Among

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Average Quality[a] of 1968 Regional Kentucky Bluegrass Varieties and Experimentals From Late Spring to Early Fall, for a Five-Year Period, 1970 Through 1974, Columbia, Missouri

A-20	6.4	P-35	5.3	Cougar	5.2	WK-408	4.8
A-34	6.0	P-116	5.3	P-77	5.1	P-72	4.8
Fylking	5.8	Galaxy	5.3	P-6	5.1	Vantage	4.8
Wk-412	5.7	Georgetown	5.3	Majestic	5.1	Newport	4.8
Sodco	5.7	P-117	5.3	Adelphi	5.0	P-38	4.8
Windsor	5.5	Palouse	5.3	P-56	5.0	P-74	4.7
Birka	5.5	P-102	5.3	P-5	5.0	So. Dakota	4.6
P-103	5.5	Prato	5.3	Minn. 6	5.0	Nugget	4.6
P-71	5.5	Belturf	5.3	Park	5.0	Campus	4.5
Bonnieblue	5.5	Pennstar	5.2	Geary	5.0	K-162	4.5
Sydsport	5.4	Primo	5.2	A-10	5.0	Delta	4.3
P-115	5.4	Merion	5.2	Kenblue	4.9	Arista	4.3
P-108	5.4	Zwartberg	5.2	S-21	4.9		
K-107	5.3	P-114	5.2	Code 95	4.9	LSD (.05)	.3

the varieties which have shown improvement are Belturf, Adelphi, Georgetown, Galaxy, Pennstar, Merion, Sydsport, and Windsor. This may be indicative of improved adaptation with maturity or merely reflect a better response of these varieties compared with others in the study to weather conditions peculiar to the summers of 1973 and 1974. All the varieties need further scrutiny to determine if there are substantial changes in quality as plots continued to mature over the coming years.

A new group of 60 Kentucky bluegrass varieties was planted in 1972 at Columbia (central), Portageville (southeast), and Mt. Vernon (southwest) Missouri as part of the second (1972) Regional Kentucky Bluegrass Variety Evaluation Study. The plantings at Portageville and Mt. Vernon are of particular interest to us since the climate at these locations approaches that of the southern bermudagrass region. Bluegrass varieties included in these tests should undergo severe summer stress at this southern end of the bluegrass belt. With only two summers of observations completed, it is too early to draw conclusions about the adaptability of these varieties, especially in southern Missouri. Nevertheless, entries P-140, Victa, Galaxy, BA-6191, Majestic, and Enmundi ranked among the top ten for 1974 summer quality at both Columbia and Mt. Vernon (observations at Portageville were incomplete). This has been encouraging and we will look forward to continued observation of these and the other varieties at the three test locations over the next several years.

KENTUCKY BLUEGRASS VARIETY EVALUATION: ILLINOIS

A.J. Turgeon

The tremendous variability within the Kentucky bluegrass species has allowed the development of many new varieties and experimental selections that differ widely in their color, texture, density, environmental and cultural adaptation, disease susceptibility, and other characteristics. Although some turfgrass writers have been critical of the commerical introduction of so many varieties, there is considerable interest among researchers in the new Kentucky bluegrasses because of the potential they offer for superior turfgrass quality under various conditions. Certainly, much work needs to be done to clarify the seemingly confusing varietal picture (what Nutter calls VD--varietal dilemma) so that turfgrass managers can take full advantage of the variability within Kentucky bluegrass in developing and sustaining the best turf possible. Thus, a multiphase varietal evaluation program is underway at the University of Illinois to accurately determine the role of the new varieties in contemporary turfgrass culture.

Phase I is the traditional variety evaluation; small replicated plots are established and maintained under a moderate intensity of culture for observation over several years. There are 52 varieties plus 10 blends and 4 mixtures from an April, 1972, planting under test at this station. Plots measure 6 x 8 feet, and each variety is replicated three times. Fertilizer is applied four times per year to supply a total of four pounds of nitrogen per 1,000 sqare feet, using a 10-6-4 analysis fertilizer. Mowing is performed 2 or 3 times per week at 1.5 inches. The turf is irrigated as needed to prevent wilt. Ten of these varieties are also being observed at two satellite stations located in Glencoe (north) and Belleville (south), Illinois.

The two diseases of principle importance this year were *Helminthosporium* leaf spot in spring and *Fusarium* blight in summer. Those varieties showing the least injury from these diseases included: A-20, A-34, Adelphi, Baron, EVB-282, Glade, K1-143, K1-155, K1-187, Majestic, Monopoly, P-59, P-140, Parade, PSU-150, PSU-190, RAM#1, RAM#2, Sydsport, Touchdown, and Victa (Table 1). Some *Sclerotinia* dollar spot was observed in Nugget and Windsor, but it did not occur extensively in the plots. The blends showed characteristics of both varietal components in most cases. For example, the Nugget-Park blend showed some leaf spot thinning, while Nugget was essentially unaffected and Park was seriously thinned. The same compromise in leaf spot incidence was evident in the Merion-Kenblue blend. The summer quality data also illustrated this averaging effect from blending. Exceptions included the Nugget-Glade blend, in which Glade appears dominant, and the Brunswick-P-59 blend in which Brunswick appears dominant. These results suggest that blends should be constructed using component varieties that are compatible in color and vigor, and that possess outstanding qualities or, at least, no serious deficiencies such as *Helminthosporium* leaf spot or *Fusarium* blight susceptibility; or use blends in which the low-quality components (fillers) disappear due to the greater vigor of the high-quality components. The Kentucky bluegrass-fine fescue mixtures have

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not been good turfs because of high disease incidence and the loss of visual quality during summer. However, the Kentucky bluegrass-perennial ryegrass (Fylking-Pennfine) has been outstanding and appears to be predominantly ryegrass after two and one-half years. A planting of over 60 new experimental selections plus some blends was made on September 7, 1974, to expand the study of Kentucky bluegrass varieties.

Varieties showing promise for commercial development are studied further in a Phase II evaluation. Six varieties of Kentucky bluegrass, including: Windsor, Nugget, Merion, Fylking, Pennstar, and Kenblue, were planted in 1972 and maintained at 1 3/4-inch height through the season. In April, 1973, all of the varieties except Windsor were clipped at 1 1/2 or 3/4 inch, three times per week, and fertilized at an annual rate of 2, 4, 6, or 8 pounds of nitrogen per 1,000 square feet, applied in one- or two-pound increments in May, June, August, and September. In the fall of 1973, A-20 sod was planted in an adjacent area and included in the study along with Windsor. Thus, seven varieties were observed at eight cultural intensities through 1974. The nitrogen source was a 10-6-4 water-soluble fertilizer. Each treatment combination (mowing height x fertility level) was replicated three times with 4- x 6-foot plots within each variety.

Results indicate that turfgrass quality is largely dependent upon disease incidence which, in turn, is associated with the mowing height and fertilization rate within each variety (Table 2). Windsor was unaffected by *Fusarium* blight, but *Sclerotinia* dollar spot was evident at the lower fertilization levels, especially in the closely clipped (3/4 inch) turf. Turfgrass quality of closely clipped turf maintained at higher fertilization rates was outstanding. A-20 was unaffected by either *Fusarium* blight or *Sclerotinia* dollar spot, but the development of yellowish, circular spots 1 to 1 1/2 inch in diameter (referred to as "yellow tuft") in plots maintained at low fertility and close mowing seriously reduced turfgrass quality. However, results did indicate that, like dollar spot in other varieties, raising the cutting height or increasing the fertilization level could reduce the incidence of this disease. Nugget was seriously thinned and discolored by *Sclerotinia* dollar spot when closely clipped, especially at the lower fertilization levels. The appearance of Nugget during the 1974 season suggests that this variety is not as well adapted to the climatic conditions of central Illinois as it is to the more northerly latitudes. Merion Fylking, and Pennstar were affected by *Sclerotinia* dollar spot at close mowing and the lower fertilization levels, while *Fusarium* blight incidence seriously reduced turfgrass quality at the higher fertilization levels. In some cases, both disease symptoms were evident in the same plot. Kenblue was seriously blighted with *Fusarium* at all cultural intensities. Twenty-two additional varieties of Kentucky bluegrass were planted in September, 1974, for testing under five different cultural intensities including: close mowing (3/4 inch) at high (6 lb. of N per 1,000 sq. ft. per year) and low (2 lb. of N per 1,000 sq. ft. per year) fertilization; moderate mowing (1 1/2 inch) at high and low fertilization; and high mowing (3 inch) at minimal fertilization (1 lb. of N per 1,000 sq. ft. per year) and no irrigation. This is an important extension of the varietal evaluation program in that it is helpful in determining the cultural requirements of individual varieties as well as the adaptation of the varieties to different cultural intensities.

A third type of varietal study, referred to as Phase III, is any specialized test for developing information beyond that determined in the Phase I and II evaluations. One such test was conducted to evaluate the competitive ability of Kentucky bluegrass varieties in closely clipped annual bluegrass. Plugs of 49 varieties were planted into 3/4-inch annual bluegrass turf in August, 1973. Plugs measured four inches (10 cm.) in diameter, and each variety was replicated four times. The plots were fertilized monthly during the growing season with 1 lb. of N per 1,000 sq. ft. Irrigation was performed as needed to maintain the annual bluegrass. Plug diameters were measured after 14 months. Results showed wide variability among varieties in their competitive ability under the experimental conditions (Table 3). The experimental selections Ba 61-91, P-140, and RAM#1 ranked quite high on the competitive scale, while Park and Galaxy apparently lacked much competitive ability relative to annual bluegrass. This information is of importance in designing a program for controlling annual bluegrass; selection of a variety or blend of varieties best adapted to conditions in which annual bluegrass invasion is likely to occur is a critical first step in preventing take-over by annual bluegrass. Other Phase III studies recently initiated include a shade adaptation study and several evaluations in which Kentucky bluegrass varieties were planted on golf tees to determine relative performance under actual conditions. No results have been obtained from these studies to date.

It is apparent from these studies that there is much to be gained from the intelligent selection and proper care of improved turfgrass varieties in contemporary turfgrass culture. Included in this is a reduction in the turfgrass manager's dependency on cultural practices that were designed to compensate for the weaknesses of a turfgrass. Thus, turfgrass management is made simpler and higher turfgrass quality is obtainable with the use of improved varieties.

Table 1. 1974 Varietal Evaluation Results With Kentucky Bluegrass Varieties, Blends, and Mixtures Planted April, 1972

	Leaf spot rating[a]	Fusarium blight rating[b]	Quality rating[c]		
			7/16/74	9/4/74	10/17/74
VARIETIES					
A-20	1.3	1.0	2.0	3.7	1.7
A-34	2.3	1.0	2.7	4.0	2.3
Adelphi (P-69)	2.3	1.0	2.3	2.3	2.7
Ba 61-91	2.3	2.7	2.3	3.3	3.0
Ba 62-55	2.7	3.0	2.3	3.3	3.0
Baron	2.3	1.0	2.7	3.7	3.3
Bonnieblue (P-106)	1.7	2.0	2.7	3.7	3.0
Brunswick (P-57)	2.3	2.3	3.0	3.7	1.7
Campina	6.0	1.0	2.3	3.3	2.7
Delft	3.0	5.7	3.0	6.0	4.0
EVB-282	2.7	1.0	2.0	3.7	3.0
EVB-305	2.0	4.3	3.0	5.3	4.3
EVB-307	1.7	2.0	2.7	4.3	2.7
EVB-391	2.0	1.0	3.0	3.3	2.7
Fylking	2.0	3.7	2.0	4.7	3.3
Galaxy (P-27)	1.3	3.0	2.3	3.3	2.7
Geronimo	1.7	3.7	2.7	4.7	3.0
Glade (P-29)	2.3	1.0	2.7	2.7	2.7
K1-131	1.7	2.0	3.0	2.7	3.0
K1-132	1.7	3.0	3.0	3.7	3.0
K1-133	2.0	2.0	2.3	3.3	3.0
K1-138	4.0	3.7	2.7	6.3	4.3
K1-143	2.0	1.0	2.3	3.0	3.0

Table 1. (cont.)

	Leaf spot rating[a]	Fusarium blight rating[b]	Quality rating[c] 7/16/74	9/4/74	10/17/74
K1-155	2.0	1.0	2.3	3.3	2.7
K1-157	4.3	4.0	2.0	4.3	2.7
K1-158	4.7	2.0	2.0	3.3	2.7
K1-187	2.0	1.0	2.7	3.0	3.0
Kenblue	5.7	1.7	2.7	5.0	3.7
IL-3817	1.7	2.7	2.0	4.3	3.0
Majestic (P-84)	1.7	1.0	2.0	3.0	3.0
Merion	1.3	1.3	2.0	3.7	3.0
MLM-18001	2.7	3.0	2.3	3.0	3.0
Monopoly	2.0	1.0	2.0	2.3	2.0
Nugget	1.3	1.7	2.7	4.7	3.3
P-59	2.0	1.0	2.7	3.0	2.3
P-140	2.0	1.0	1.3	3.0	1.7
Parade	2.0	1.0	2.3	3.0	2.7
Park	6.7	2.7	2.0	4.7	3.3
Pennstar	1.7	1.3	2.7	4.7	3.0
Plush (P-133)	2.3	3.3	2.3	3.3	2.3
PSU-150	1.7	1.0	1.7	2.7	2.7
PSU-169	1.3	2.7	2.0	3.7	2.3
PSU-190	1.7	1.0	2.3	3.0	3.0
PSU-197	2.3	3.7	2.3	6.3	3.3
RAM #1	2.3	1.0	2.7	3.3	2.7
RAM #2	1.7	1.0	2.7	3.0	2.3
Sodco	2.7	2.0	2.0	3.7	3.0
Sydsport	2.3	1.0	2.3	3.0	2.7
Touchdown (P-142)	2.0	1.0	3.0	2.0	2.3
Vantage (Ba61-24)	4.3	1.3	2.3	3.7	2.7
Victa (Ba62-54)	2.0	1.0	2.7	3.7	3.0
Windsor	3.7	1.0	2.3	3.0	2.3
BLENDS					
Merion + Kenblue	3.0	2.7	2.3	4.7	3.0
Merion + Pennstar	1.7	2.0	2.0	4.3	3.0
Merion + Baron	2.0	1.7	2.0	3.7	3.0
Nugget + Pennstar	1.7	1.3	2.7	4.0	2.7
Nugget + Park	3.3	2.0	2.3	4.7	3.0
Nugget + Glade	1.7	1.0	2.7	3.0	2.7
Nugget + Adelphi	1.3	1.7	2.3	3.7	3.0
Victa + Vantage	1.7	1.3	2.0	3.7	2.3
P-59 + Brunswick	1.3	2.3	2.0	4.7	1.7
Blend 38	2.3	1.7	2.7	3.7	2.7
MIXTURES					
Fylking + Jamestown (RF)	1.7	3.7	2.7	6.7	3.0
Fylking + Pennlawn (RF)	2.3	3.7	2.3	6.0	3.0

Table 1. (cont.)

	Leaf spot rating[a]	Fusarium blight rating[b]	Quality rating[c]		
			7/16/74	9/4/74	10/17/74
Fylking + C-26 (HF)	2.0	2.7	2.7	5.3	3.0
Fylking + Pennfire (PR) . . .	1.3	1.0	2.0	2.7	3.0

[a]Leaf spot ratings were made on May 4, 1974, using a scale of 1 through 9 with 1 representing no disease; 2 and 3 indicating some thinning of the turf; 4 to 6 indicating some blighting; and 7 to 9 indicating severe blighting of the turf.
[b]Fusarium blight ratings were made on August 31, 1974, using a scale of 1 through 9 with 1 representing no disease and 9 representing complete blighting.
[c]Visual quality was measured using a scale of 1 through 9 with 1 representing best quality and 9 representing poorest quality.

Table 2. Effects of Fertilization and Mowing Height on Turfgrass Quality of Seven Kentucky Bluegrass Varieties on September 3, 1974[a]

lb. N/100 sq. ft.			Mowing	Kentucky bluegrass variety						
May	June	Aug.	height (in.)	Windsor	A-20	Nugget	Merion	Fylking	Pennstar	Kenblue
1	0	0	.75	5.7	6.0	8.0	5.7	5.3	5.0	5.7
1	0	0	1.50	4.7	2.3	5.0	4.7	5.0	5.3	7.0
1	1	1	.75	3.3	4.3	6.0	5.7	4.7	5.3	6.0
1	1	1	1.50	2.7	2.7	4.7	5.3	5.0	6.0	6.0
2	1	1	.75	2.3	3.7	5.7	5.3	6.0	7.0	6.7
2	1	1	1.50	2.0	2.3	4.3	5.0	5.3	6.3	7.3
2	2	2	.75	2.3	3.3	5.0	6.3	7.0	7.3	6.3
2	2	2	1.50	2.0	2.7	3.7	6.7	6.0	7.0	7.0

[a]Table data are the means of three replications. Observations were made using a scale of 1 through 9 with 1 representing best turfgrass quality and 9 representing very poor turf.

Table 3. Competitive Ability of Kentucky Bluegrass Varieties in 0.75 Inch Annual Bluegrass Turf

Plug diameter (cm.)	Cultivar
Over 10.	Ba 61-91
9.9 - 9.0.	P-140, RAM #1
8.9 - 8.0.	A-20, EVB-305 > P-59, MLM-18001 > Touchdown, Parade, PSU-190 > Glade, Baron, Brunswick, PSU-169, PSU-150
7.9 - 7.0.	P-133, Kenblue > A-34, K1-132 > Adelphi, Sydsport > EVB-391
6.9 - 6.0.	K1-143 > Geronimo, Sodco, K1-133, K1-138 > Windsor, Nugget
5.9 - 5.0.	Ba62-55, Pennstar, RAM #2, EVB-282, K1-155, 1L-3817 > Victa > Bonnieblue, PSU-197
4.9 - 4.0.	K1-187 > Merion, Vantage > Fylking, EVB-307
3.9 - 3.0.	K1-131 > Majestic, Campina > Monopoly
2.9 - 2.0.	Park > Galaxy

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Hubbard Trail Country Club
Bacil B. Hurr Landscaping
Illini Country Club
Illinois Lawn Equipment
Illinois State University
Imperial Landscaping
Indian Lakes Country Club
Inverness Golf Club
Jacobsen Manufacturing Co.
Joliet Lawn Service
Kankakee Country Club
Kasik & Sons Landscaping
Keller-Heartt Co.
Kewanee Park District
Kipp's Lawnmower Sales
Chas. Klehm & Son
Knollwood Country Club
LaCroix Agency
La Grange Country Club
Lake Cook Farm Supply
Lakeview Country Club
Lake View Memorial Gardens
Land Stylists
Landscape Maintenance
Lawn-A-Mat
Lawnkeepers
Lawn Medic of Pekin
Lawn Medic of Peoria
Lawrence & Ahlman
LeRoy Country Club
Lincoln Greens Golf Club
Liqui-Green, Inc.
Liqui-Green Suburbia
Lockhaven Country Club
Loft-Kellogg, Inc.
Lofts Pedigreed Seed
Lombard Park District
Lockport Township Park
Loyola University Med.
Mallinckrodt Chemicals
McCann Lawn Sprinkling
McGinty Bros. Inc.
Medinah Country Club
Michael's Lawn & Landscaping
Midlothian Country Club
Midwest Country Club
M.A.G.C.S.
Mill Creek Country Club
Mott Corp.
Mt. Emblem Cemetery Assn.
Mt. Prospect Park District
Mueller Farms Sod Nursery
Muellermist Irrigation
Naperville Country Club
Nordic Hills Country Club
Norridge Park District
Northmoor Country Club
Northrup, King & Co.
North Shore Spray Service
Oak Brook Landscape
Oak Hills Golf Club
Olympia Fields Country Club
Paul Owens Landscaping
Edward Lawrence Packard
Park District of Oak Park
Park PM Corp.
Pekin Park District
Perfection Mfg. Co.
Peterson Landscape
Pinecrest Golf & Country Club
Prestwick Country Club
The Rail Golf Club
Ravinia Green Country Club
Reliable Sod Nursery
Resurrection Cemetery
Ridge Country Club
Ridgemoor Country Club
Ridgewood Commercial H.S.
Rite Landscape Service
Rogala Public Links
Rolling Green Country Club
St. Andrews Golf and Country Club
John W. Schnaufer
Schultze's Little Nursery
Scott AFB
Scotts Pro Turf
Scruggs-Drake Equipment Co.
Seaboard Seed Co.
Shamrock Turf Nursery
Short Hills Country Club
Leon Short & Sons
Joe Sidari Landscaping
Silver Lake Country Club
Skokie Country Club
Soagetaha Country Club
Sod Now, Inc.
S.I.G.C.S.A.
Southside Country Club
Sportsman Country Club
Springfield Park District
Sprinkler Irrigation
Sprinkler Irrigation
Stauffer Chemical
R. Stevenson, Inc.
South Stickney Park District
Sunnybrook Landscaping
Ralph Synnestvedt
Teske Seed & Feed
Thornton's Turf Nursery
Timber Trails Country Club
Triton College
Turf Products
Turnberry Country Club
Chicago University
Urbana Park District
Valparaiso Golf Club
Vaughan-Jacklin
Velsicol Chemical
Village Greens of Woodridge Country Club
Village Links
Wadsworth Co.
Warren's Turf Nursery
Waukegan Park District
Wee-Ma-Tuk Hills
Wilmette Park District
Woodmar Country Club
Woodridge Golf Club