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Factors Associated With Iron Chlorosis of Kentucky Bluegrass Cultivars[1]

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Turfgrass production is a unique branch of agriculture: success is measured by appearance rather than by total production. Color, which comprises a large portion of quality, is directly related to the chlorophyll content of the shoot. One of the main goals in turfgrass production, therefore, is to produce chlorophyll.

An unacceptable green turfgrass color (chlorosis, can result from problems such as nutritional deficiencies, infestation by certain insects or diseases, and extended periods of cloudy weather. (Of course, the genetic makeup of a given turfgrass species or variety always plays a large role in chlorophyll production, particularly under adverse environmental or pathogenic influences.)

Turfgrass chlorosis in much of the western United States generally is due either to nitrogen or iron deficiency. In alkaline soils, low available iron is the primary cause of. turfgrass chlorosis. Chlorosis occurring in lawns receiving nitrogen on a regular basis is also often a symptom if iron deficiency. In this case, leaf blades show interveinal yellowing, while veins remain green. Growth otherwise appears normal, except under severe conditions. (An acute shortage of available iron may cause a bleached, almost white, appearance). If iron deficiency is severe and continues for an extended period, the turfgrass will die.

As is the case for other plants, iron chlorosis appears first in newly developed leaves, the entire shoot becoming yellow only under prolonged conditions of deficiency. Yellowing, then, will not be uniform over the entire area of sod. It appears as randomly scattered spots, creating a mottled appearance. This mottling is typical of a micronutrient deficiency and is an aid in distinguishing iron deficiency from nitrogen deficiency.

In the study described here, we evaluated the susceptibility of Kentucky bluegrass *(Poa pratensis L.)* cultivars and blends to iron chlorosis and related iron and chlorophyll content to appearance.

Materials and Methods

Experimental plots of 25 cultivars and five blends of Kentucky bluegrass were established at Colorado State University, Fort Collins, in 1971 — 3 years before the start of this experiment. Varying degrees of chlorosis within the plots led to this comparative study. Plots, 5 by 10 feet, were replicated three times in a randomized complete block design and were mown twice a week to a height of ¾ inch.

Colors were visually estimated with a range of 10 to equal dark-green and 1 to equal light-yellow.

Samples for chlorophyll and iron determination were collected on September 25. 1974. 3 days after plants had been mown to a height of ¾ inch. Immediately after harvest, samples were rinsed with distilled water to eliminate surface contamination, oven-dried. Throughout the test. plant material was kept in the dark to minimize chlorophyll breakdown. Chlorophyll and iron determinations were made according to accepted procedures.

At the time of tissue sampling, five soil samples were

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taken from each plot 4 inches below the thatch layer, and a composite was then made for the plot. Soil pH and iron were determined. again according to accepted soil chemistry procedures.

A routine nutrient analysis (following) was done at the Colorado State University Soils Laboratory on one composited soil sample from the entire area.

Texture	pH	Salts (mmhos/cm)	Organic matter %	Nutrient content (ppm) NO_3N	P	K	Zn	Fe
Sandy clay	73	06	2.6	19	13	303	0.9	13.5

Results and Discussion

Neither soil pH nor available iron of the individual plots were significantly different. The pH was 7.4 ± 0.1 for each plot, and the available soil iron ranged from 9.1 to 17.9 ppm.

Available iron was sufficient to satisfy the iron needs of certain cultivars and produced turf that did not display chlorosis. A significant difference among cultivars and blends occurred in total content of iron (see table). Thus, some cultivars are more efficient in absorbing iron from the soil than others.

Visually-determined color ratings were compared with chlorophyll content of the turfgrass. Chlorophyll contents lower than 2.17 mg/g were associated with the light-green color. The table shows that chlorophyll content appears to be at least one factor that influences color difference among Kentucky bluegrass cultivars and blends. The following cultivars and blends showed severe chlorosis:

'Adelphi,' Ill. 38-17, 'Sodco,' 'Sydsport,' 'Windsor,' and blends of 'Common' + 'Kenblue' and 'Windsor' + 'Merion' were rated dark-green. 'Warren's A-20' and 'A-34,' 'Park,' 'Arboretum,' 'Nugget' and blends of 'Fylking' + 'Pennstar' + 'Nugget' and 'Park' + 'Delta' + 'Newport.'

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Mean Values for Plant Fe, Chlorophyll Content, and Color Ratings of Kentucky Bluegrass Cultivars and Blends from Three Replicate Plots

Cultivar or blend	Color rating*	Chlorophyll (mg/g)	Total plant Fe (ppm)
Adelphi	10	2.27	271
Ill 38-17	10	3.56	296
Sodco	10	3.20	273
sydsport	IO	2.90	266
Windsor	10	2.93	268
Fylking	9	2.88	270
Newport	9	2.62	224
Prato	9	2.75	250
Baron	8	2.53	233
Code 95	8	2.63	224
Common #l	8	2.60	236
Delta	8	2.73	248
Geary	8	2.69	246
Kenblue	8	2.69	262
Pennstar	8	2.54	203
Common #2	7	2.55	226
Melle	7	2.45	211
Prim0	7	2.42	183
s 21	7	2.27	202
Merion	6	2.33	177
Warren's A-20	5	2.16	172
Park	4	2.08	198
Arboretum	3	2.07	164
Nugget	2	1.53	165
Warren's A-34	2	1.68	155
Common+Kenblue	10	3.65	275
Windsor+Merion	10	2.72	262
Merion+Delta	7	2.31	176
Fylking+Pennstar+Nugget	5	2.17	175
Park+Delta+Newport	3	1.74	171
Mean	7.3	2.47	222
H.S.D.(l%level)		1.50	116

* 1 = light yellow, to 10 = dark green

Sod Rooting

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A seeded turf can require 4- to 8- months growth before it is playable. For this reason, many sports fields are sodded to new turf because it becomes playable within 2 to 4 weeks after being installed. Most commercial sod is grown on clay loam soil. When cut, its soil layer ranges in thickness from 1/2 in. to 1 in. This thin layer of soil causes few, if any, problems when the sod is laid on clay or clay loam soil. When unwashed sod is placed on a sand or sand/organic base, its thin layer of clay loam can greatly alter the whole concept of using sand as the growing medium for a sports field.

Well-grown sod, properly managed, should quickly knit laterally and develop new roots into the medium upon which it is laid. This surface layer of soil brought in with the sod governs the infiltration rate of water into the medium below it and holds more moisture than a sand or sand mix. Rooting into the medium, therefore, can be differentially affected. The thin surface layer of soil also is compactible, further reducing the downward movement of water and air to the sand medium. Frequent hole punching and removal of the soil portion of the plugs is one way to manage the field back to its original condition as a sand field. Its effectiveness will depend on the frequency of hole punching, the removal of plugs, the thickness of the surface soil layer, and the type of sand used in construction.

Another solution has been to wash the soil from the sod before laying it. At least one major sod producer has developed a commercial method for washing the soil from the sod. Washed sod has been used on fields of several large sports stadiums. Washed sod samples taken at one site showed the removal of silt and clay to range between 75 and 90 percent.

Various problems have arisen with the use of washed and unwashed sod when laid on a distinctly different medium sometimes due to mismanagement and sometimes because it is not understood what to expect under field conditions. To explore and solve these problems, a study was initiated at Davis September 4, 1979, to evaluate rooting and growing conditions where washed sod and unwashed sod were placed on three various media.

Using our old experimental practice green, a 4-inch depth of the existing bentgrass sod was removed to expose the three original media: (1) Dillon Beach sand which is a very uniform, relatively fine sand recommended for all types of high use athletic areas; (2) Robertson sand, a washed, uniform but coarse sand more typical of a plaster sand; and (3) a loamy sand mix made up of six parts Robertson sand. two parts Yolo loam and two parts sphagnum peat moss. (See Table 1 for particle size distribution of these media.)

The individual 8- by 17-foot plots were divided; commercial sod was laid on one half and washed sod on the other half. In order to wash the soil from the rolls of sod, they were laid, grass side down, on 1/2 inch heavy-gauge hardware cloth benches. Spray nozzles attached to garden hoses were used to wash the soil from the sod. The commercial sod was delivered at noon on Tuesday, September 4, 1979, and washed and laid the following morning.

The week before sodding, the experimental area was cultivated, regraded, and deeply irrigated. Just before laying the sod, 16- 16- I6 fertilizer was applied at the rate of 6 pounds of fertilizer per 1,000 square feet. After laying the sod, the area was irrigated twice daily. During the fall and winter months.

Table 1. Particle Size Distribution of the Three Media

Sieve no.	Sieve Size dia. (mm)	Percent weight retained: Dillon Beach		Robertson		Loamy Sand Mix	
10	2.00 plus	.17		0.0		0.0	
			.34		a.30		5.03
18	1.00 - 2.00	.17		8.30		5.03	
35	0.50 - 1.00	1.40		52.10		31.43	
60	0.25 - 0.50	57.33	96.23	33.80	89.70	25.50	69.79
140	0.10 - 0.25	37.50		3.80		12.86	
270	0.05 - 0.10	.86		.33		6.66	
Silt	0.002- 0.05	1.00	2.86	.50	1.83	11.00	23.66
Clay	- 0.002	1.00		1.00		6.00	

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it was irrigated once during each week if it did not rain that week.

In order to quantitatively evaluate rooting during establishment, four random samples were taken from each washed and unwashed plot. A6-in. deep, 3-in. wide, 1/2-in. thick turf soil profiler was used to take samples. The profile was placed on a wire grid which had barbs sticking out to hold the profile during growing medium removal. The medium was carefully washed using a fine spray mist nozzle over the sample. As the roots became exposed, they would adhere to the barbs on the wire grids. The new roots which had grown into the media were dried and then removed from the wire grid and weighed on a sensitive balance.

Samples were taken weekly from the third week after installation through the ninth week (late September through early November).

Results

When root weights were averaged across the three media, it was found that rooting from the washed sod was more than twice that of the unwashed sod from the third through the ninth week, as is shown in Fig. I. When the rooting pattern was examined in terms of the three media (Table 2). it was noted that the Dillon Beach and Robertson sand media showed highly significant increase in rooting when the sod was washed as compared to unwashed sod. There were no significant differences between washed and unwashed sod when it was laid on sandy loam. It was determined that washed sod rooted far superior in the fine sand (Dillon Beach) than any of the other treatments as shown in Table 2.

Figure 1: Average Might of Washed-Versus-Unwashed Treatments During the Estabishment Period (Weeks 3 through 9)

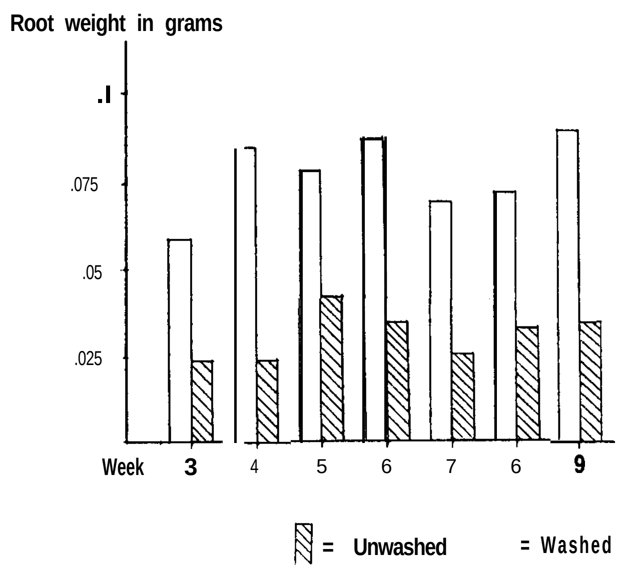


Table 2. Mean Total Root Yields, in Grams, for ths Three Media and Two Washing Treatments (September through November).

Soil type'	Mean†	Ranking
DW	.128a	1
RW	.072b	2
D	.045b	3
SW	.036bc	4
R	.026cd	5
S	.017cde	6

P=.Ol LSD=.0418

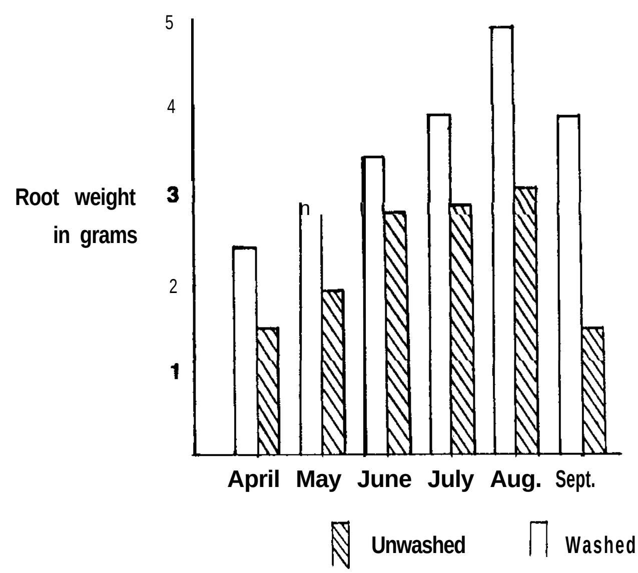
'DW = Dillon Beach sand-washed sod
RW = Robertson sand — washed sod
SW = Loamy sand mix — washed sod
D = Dillon Beach sand — unwashed sod
R = Robertson sand — unwashed sod
S = Loamy sand mix — unwashed sod

†Values followed by the same letter are not significantly different at the 5% level of probability.

Starting the following April, 1980, the beginning of the new growing season, samples were collected and compared every four weeks through September, 1980. Root weights were determined as previously described. Plot maintenance consisted of twice-a-week watering with I .25 inch per application time, once a week mowing at 2 inch height, and two applications of ammonium sulfate at the rate of 1 pound of nitrogen per 1000 square feet once in April and again at the end of August.

Comparing the root yields for the last six months of the treatment period, the washed sod yielded significantly more roots than the unwashed sod, but the differences were not as great as they were during the establishment period (Fig. 2).

Figure 2: Average Root Might of Washed vs. Unwashed Sod Roots (April Through September, 1991)



When the results were examined in terms of the soil media, as given in Table 3, it was found that the Dillon Beach washed sod had the greatest root yield, followed in ranked order by Robertson washed, Dillon unwashed, mix washed, Robertson unwashed, and mix unwashed.

Table 3. Mean Total Root Yields in Grams, for the Three Media and Two Washing Treatments. (April through September, 1981)

Soil type'	Mean+	Ranking
DW	.525a	1
RW	.391b	2
D	.318bc	3
SW	.293bcd	4
R	,241 cde	5
S	.229cde	6

P= .Ol LSDat1%=.1149

'DW =Dillon Beach sand — washed sod
RW =Robertson sand — washed sod
SW = Loamy sand mix — washed sod
D =Dillon Beach sand — unwashed sod
R =Robertson sand — unwashed sod
S =Loamy sand mix — unwashed sod

The results of this study gave evidence that differences occurred between the rooting characteristics of washed sod and unwashed sod. Rooting of washed sod into sand medium is much more substantial than into unwashed sod. It is indicated that the soil brought in on sod can affect subsequent root growth, especially if that unwashed sod is placed on a sand base. It is apparent that the right growing media for environmental maintenance conditions do play an important part in root development of washed sod and should be considered carefully to grow a successful turf sward with a healthy and extensive root system.

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UC TURF CORNER

UC Turf Corner contains summaries of recently reported research results, abstracts of certain conference presentations, and announcements of new turf management publications. The source of each summary is given for the purpose of further reference.

Effects of Turfgrass on Woody Plants Establishment

Results from experiments by researchers at the University of Rhode Island indicate that the suppression of woody plants by turfgrasses may involve chemical inhibition by leachates from grass roots as well as direct competition for available nitrogen.

A field study was conducted for two growing seasons to evaluate the growth of flowering dogwood and forsythia in established sod. Treatments included different-sized areas of turf-free space, surface and subsurface placement of fertilizer and irrigation, and two mowing heights. Turfgrass significantly reduced the growth of both woody species, the Rhode Island scientists report.

Although supplementary fertilizer, applied as a topdressing, failed to benefit the ornamentals, subsurface treatments resulted in considerable growth increases. Competition for moisture didn't appear to be responsible for the growth differences observed, because maintaining a high level of soil moisture failed to overcome the inhibitory effects of the turfgrass. Competition for nitrogen, however, was indicated by results of leaf tissue analysis.

A bioassay experiment was conducted to test the hypothesis that the competitive nature of turfgrasses involves an allelopathic mechanism. Aqueous leachates of the roots of perennial ryegrass, red fescue, and Kentucky bluegrass were applied to rooted cuttings of forsythia. Top growth of the forsythia was inhibited by leachates from all three turfgrass species. Root growth was suppressed by ryegrass and red fescue leachates.

(See "Effects of Turfgrass on the Establishment of Woody Plants," by S. L. Fales and R. C. Wakefield, *Agronomy* Journal, Vol. 73, No. 4, July-August 1981.)

Water Consumption, Growth Rate of 11 Grasses Under Different Mowing, Irrigation Regimes

Researchers at the Hebrew University of Jerusalem recently determined the water consumption and growth rate of 11 turfgrass species or cultivars grown during the summer under different mowing and irrigation regimes.

They found that water consumption by the two cool-season grasses included in their experiments-tall fescue and perennial ryegrass-was considerably higher than for the nine warm-season grasses tested. The warm-season grasses included kikuyugrass, St. Augustine, Kuntze (the common species and a dwarf cultivar), *Paspalum vaginatum Sw.*, centipedegrass, bermudagrass, emerald zoysiagrass and matrella zoysiagrass. The growth rate of the cool-season and warm-season grass was similar.

The single most important factor in determining water consumption by the grasses tested, the Israeli scientists report, was their photosynthetic pathway. The cool-season (C-3) grasses showed a 45 percent higher water consumption than the warm-season (C-4) grasses.

Lowering the irrigation frequency resulted in a decrease of water consumption from 6 to I8 percent and 24 to 34 percent for the C-4 and C-3 grasses, respectively. Increasing shearing height from 3 to 6 centimeters (1.2 to 2.4 inches) resulted in an increase of water consumption from 3 to 15 percent for C-4 grasses and 25 to 29 percent for C-3 grasses.

In the experiments, the transpiration ratio of the C-3 grasses was almost double that of the C-4 group, and the values were consistent with those found for other plants belonging to the same carbone fixation pathway.

Two types were observed among the C-4 warm-season grasses: (1) sparse, tall growing grasses which had a high yield and a high water consumption; (2) dense, low growing grasses which were lower in yield and water consumption.

Based on the results of their experiments, the Israeli researchers note that although the choice of a species or cultivar of turfgrass usually is made on the basis of temperature adaptation, if the criterion is water consumption in relation to availability and cost, then C-3 (cool-season) varieties shouldn't be chosen for warm semi-arid zones to the extent that is practiced now.

(See "Water Consumption and Growth Rate of 11 Turfgrasses as Affected by Mowing Height, Irrigation Frequency, and Soil Moisture," by 1. Biran, B. Bravdo. I Bushkin-Harav, and E. Rawitz, *Agronomy Journal*, Vol. 73, No. 1, Jan.-Feb. 1981.)

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