COOPERATIVE EXTENSION UNIVERSITY OF CALIFORNIA

California Turfgrass Culture

Volume 44 1&2, 1994

Traffic Effects on Turfgrasses Under Restricted Light

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Turfgrass is often grown in sites that are shaded. The performance of shade-affected turfgrass that has been subjected to sports-type traffic is not well understood, therefore a study at the University of California, Riverside, was conducted to investigate the minimum light requirement of various turfgrasses that are used for sports facilities.

The Facility. The Light Intensity Turf Evaluation (LITE) facility has been designed to submit turf to various light intensity regimes and simulated sports traffic. A structure using cables and winches was built to allow access for turf maintenance and experimental treatments. The shade cloth can be lifted completely off the surface to a height above the pattern-throw of the sprinklers. The entire treatment/ maintenance procedure including traffic application, mowing, and irrigation can be done by one person in about 2 hours.

The facility has been designed to submit turf to four photon flux density regimes. Photon flux density is the light falling on a surface that is used by a plant for photosynthesis. It is measured in photosynthetically active radiation (PAR) and is expressed as micromols per square meter per second (μmol m^{-2} s^{-1}) photons. Turf managers, and most scientists, usually think of this simply as light intensity. The PAR treatments evaluated included full sun, with canopies that gave light restriction of 33, 54, and 78% of full sunlight. Remote data acquisition sensors collected data on PAR, air temperature, and relative humidity within the treatments which were transmitted via infrared telemetry to a computer.

Simulated Traffic. Cleated-shoe traffic on a sports field is composed of three components: (i) wear from friction and scuffing; *(ii)* compaction from the shoe sole and the concentrated weight distribution of the cleat; and *(iii)* shear injury to the grass plant from the twisting of the embedded cleats.

To conduct research for sports fields, it is necessary to use a device to uniformly simulate traffic imposed by sports that use a cleated shoe.

The Brinkman Traffic Simulator (BTS) was developed to uniformly simulate the traffic of American football when applied to turfgrass research plots (1). The BTS consists of two cleated rollers in a frame connected by a chain and sprockets which is pulled by a small tractor. The size of the cleats is approximately that on the shoe of professional football linemen.

The BTS provides wear by being pulled over the turf. Compaction is accomplished by the weight of the machine on the cleats. The rollers are forced to turn at different speeds because of the differential sprocket size creating shear and tearing of the turf and soil. The BTS has been calibrated for professional football traffic simulation by studying actual football games to determine the location and quantity of traffic.

In this study, the turf received an average of four football game equivalents per week from October 1990 through May 1991.

Turfgasses. The turfgrasses evaluated were ‘Bonsai’ tall fescue *(Festuca arundinaceae),* ‘Manhattan II’ perennial ryegrass *(Lolium perenne),* ‘Manhattan II’ mixed with ‘Jaspar’ creeping red fescue *(Festuca rubru),* and ‘El Toro’ zoysiagrass *(Zoysia juponica).* The cool-season grasses were established by seed in April 1990, and the ‘El Toro’ zoysiagrass was sodded in June. All treatments were considered to be mature at the initiation of the traffic treatments.

Maintenance. The mowing height for the duration of the study was 1.25 in. once per week. Irrigation was as needed on all treatments. The plots were fertilized with ammonium nitrate at 1 lb of nitrogen per 1000 sq ft every 6 weeks. No other cultural practices were performed.

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Measuring. Data taken included turf scores which are visual ratings that account for turfgrass quality factors such as color, texture, density, and uniformity. Turf hardness measurements were taken with a Clegg Impact Tester, which measures the peak deceleration of a 5.5-lb (2.2-kg) missile dropped onto a surface. Harder surfaces record a higher number of units (G_{max}), indicating a lower capability of absorbing impact. Footing or traction was determined using a traction plate, which is cleated, 92.5lb (42-kg) steel plate dropped into the turf. The force required to turn the plate in turf is recorded as meter-kilogram torque (m-kg).

RESULTS

Sensor Data. High- and low-temperature measurements showed differences between the various light treatments. Daily maximum temperatures did tend to be cooler under the denser shade. At night, the denser shade canopies were warmer as they retained heat and the effect of the insulation was apparent.

Relative humidity measurements showed differences between treatments, with the 73% treatment slightly higher at night and lower in the daytime than other treatments.

At four recorded dates at 2:00 p.m., the unrestricted light level (full sun) ranged from 1200 to 1900 μmol m^{-2} s^{-1} photons with the most restricted, 73% shade, from 300 to a little over 400 μmol m^{-2} s^{-1} photons (Table 1).

Table 1. Light intensity at four dates in 1991 for the unrestricted and restricted light treatments, in pmol m^{-2} s^{-1} photons.

	Date (2:00 p.m.)			
Shade	3/23	4/03	5/31	7/05
%				
73	321	353	413	376
55	525	588	708	662
30	832	925	1267	972
0	1223	1348	1883	1528

The number of hours per day the turf was exposed to a particular light intensity indicates the potential accumulation of radiant energy. Light energy accumulated by the plant is utilized in photosynthesis which supports growth. Truly shade-tolerant plants, such as found in jungle canopies, can reach maximum net photosynthesis at 100 μmol m^{-2} s^{-1} photons, while it may require 15 times that level for a sun species (2).

For the turf in the most restricted light treatment, 73% shade, light accumulation was quite low with a few hours at the range between 300 and 400 μmol m^{-2} s^{-1}. This is equivalent to visible light experienced in a moderately lighted room. Table 2 shows the accumulation of light for 1 day, March 28, 1991.

Turf Scores. In December 1990, the effect of increasing shade on the grasses and the difference between the turfgrasses in their response to the traffic and shade were significant (Table 3). Turf quality deteriorated with light reduction. Zoysiagrass performed significantly better than the other three

Table 2. Number of accumulate hours of radiant energy (light) for four shade treatments, in μmol m^{-2} s^{-1} photons on March 28, 1991.

	Shade Treatment (hours)			
Light	0	30	55	73
	%			
100	12	11	11	10
200	11	10	9	8
300	11	10	7	6
400	10	9	7	1
500	9	8	6	
600	9	7	3	
700	9	6	1	
800	8	6		
900	7	5		
1000	7	3		
1100	6	2		
1200	6			
1300	5			
1400	4			
1500	3			
1600	1			

Table 3. Turf scores of turfgrasses in various light intensities submitted to sports traffic. (9 = excellent turf; 1 = no turf).

TURF	SHADE	12/17	2/26	4/05	5/31
	-%-				
Tall **Fescue**	0	6.8	5.0	5.0	3.3
	33	6.0	4.8	4.5	3.8
	54	5.8	4.0	3.5	3.5
	73	4.5	3.5	3.8	2.8
Per. Rye+ CRF	0	6.5	6.0	5.8	4.3
	33	5.5	5.5	5.5	5.3
	54	4.3	4.5	4.0	4.3
	73	3.3	3.3	3.3	3.5
Per. Rye	0	6.3	6.0	5.3	4.8
	33	5.8	5.5	5.0	5.0
	54	4.8	4.5	4.8	5.3
	73	3.3	3.3	3.3	3.5
El Toro Zoysia	0	9.0	6.8	6.5	5.5
	33	8.8	6.0	6.0	5.0
	54	9.0	5.5	4.5	2.8
	73	8.8	4.3	3.0	1.3

ANOVA three factor factorial contrast linear analysis.

12/17. Significant: shade; variety (1-3 vs 4, 1 vs 2+3); shade x variety (1-3 vs 4).

2/26. Nonsignificant: shade x variety (1-3 vs 4). Significant: shade; variety (1-3 vs 4, 1 vs 2+3); shade x variety (1 vs 2+3).

4/5. Nonsignificant: shade x variety; variety (all). Significant: shade.

5/31. Significant: shade; variety (1 vs 2+3); shade x variety (1-3 vs 4, 1 vs 2+3).

grasses. Also, it was found that fescue performed better than perennial ryegrass and perennial ryegrass mixed with creeping red fescue at the December date.

In December, 2 months after traffic was initiated, the zoysiagrass turf provided an excellent sports surface at the 73% light restriction. The tall fescue, at 73%, was marginally acceptable as a turf, but good at 54% shade. The perennial ryegrass and perennial ryegrass plus creeping red fescue were of marginal quality at 54% shade, and at 73 % shade, they had some turf cover, but of poor quality.

In February, the zoysia was still significantly better than the other grasses and the effect of shade was not as prominent as with the other grasses. At this date, the two perennial ryegrass treatments performed better than the tall fescue.

By April and May, the turf quality of all grasses deteriorated with increased light restriction. The zoysia was generally significantly better in April, with none of the four turfs rating acceptable under the 73 % light restriction. In May, the traffic and shade had severely reduced the cover of the tall fescue and the zoysia at 54 % and 73 % shade.

Surface Hardness. Surface hardness increased over time in the study (Table 4). Shade made less difference in the development of surface hardness from the traffic application than the difference in turfgrass. In January, the two perennial ryegrass treatments were significantly less impact absorptive than either the tall fescue or the zoysiagrass. In all treatments, zoysiagrass was significantly more absorptive of impact.

Traction. Shade overall did not make a significant difference in traction measurements (Table 5). Zoysiagrass characteristically has strong stolons and tends to provide greater traction than the cool-season grasses evaluated. There was significant zoysiagrass traction deterioration in the most severe light restriction treatment under traffic. Tall fescue was significantly better than the perennial ryegrass treatments. Perennial ryegrass mixed with creeping red fescue was significantly better than the ryegrass alone.

Table 4. Clegg impact on grasses in various light intensities submitted to sports traffic: G_{max}; 2.5kg missile.

		Light Restriction (%)			
Species	Date	0	33	54	73
Tall Fescue	1/23	52.3	51.8	50.4	54.8
	5/16	87.2	84.7	68.6	81.4
PR/CRF	1/23	64.9	61.6	53.3	50.0
	5/16	90.7	102.1	88.8	80.7
Per. Rye	1/23	57.3	66.9	54.3	46.1
	5/16	85.8	86.2	93.1	77.7
Zoysia	1/23	31.1	31.0	31.7	29.0
	5/16	54.5	61.9	48.3	45.9

ANOVA three factor factorial contrast linear analysis.
1/23. Nonsignificant: shade; variety (2 vs 3); shade x variety (2 vs 3). Significant: variety (1-3 vs 4, 1 vs 2+3), shade x variety (1-3 vs 4, 1 vs 2+3).
5/16. Nonsignificant: shade; shade x variety. Significant: variety (1-3 vs 4, 1 vs 2+3, 2 vs 3).

Table 5. Traction plate on grasses in various light intensities submitted to sports traffic (meter-kilogram torque).

		Light Restriction (%)			
Species	Date	0	33	54	73
Tall Fescue	1/23	4.7	4.9	4.3	4.2
	5/16	5.0	5.1	4.9	4.7
PR/CRF	1/23	4.0	4.2	4.2	3.6
	5/16	4.5	5.2	5.0	5.3
Per. Rye	1123	4.4	4.3	4.2	3.6
	5/16	4.3	4.7	4.5	4.4
Zoysia	1/23	6.3	6.1	6.5	7.1
	5/16	6.9	6.6	5.7	4.8

ANOVA three factor factorial contrast linear analysis.
1/23. Nonsignificant: shade; variety (2 vs 3). Significant: variety (1-3 vs 4, 1 vs 2+3); shade vs variety (1-3 vs 4, 1 vs 2+3).
5/16. Nonsignificant: shade. Significant: variety (1-3 vs 4, 1 vs 2+3, 2 vs 3); shade x variety (1-3 vs 4); traffic vs variety (1-3 vs 4).

CONCLUSIONS

El Toro zoysiagrass has good traffic tolerance under full sun and severe light restrictions. Perennial ryegrass and tall fescue also perform well under football-type traffic even with several light restrictions. The addition of creeping red fescue does not increase the traffic tolerance of perennial ryegrass.

The zoysiagrass, perennial ryegrass, and tall fescue were at least showing minimal traffic performance for nearly 5 months at a light level of about 6 hours per day of 300 μmol m^{-2} s^{-1} photons of PAR. Perennial ryegrass performed well at 6 hours per day of 500 with an additional 3 hours per day of 600 mmol m^{-2} s^{-1} photons of PAR. This study indicates that perennial ryegrass, tall fescue, and zoysiagrass will grow in low light of the correct type to provide a sports turf cover.

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Effects of Nitrogen and Potassium on High-Trafficked Sand Rootzone Turfgrass

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Sand rootzone sports fields are considered to be state-of-the-art on high use and high-visibility facilities where construction and maintenance budgets are adequate. The sand rootzone can tolerate compaction from players, equipment, and attendees better than other media and will provide good water and air infiltration and percolation to sustain turfgrass growth and insure the best possible traffic tolerance for the grass sward. Of course, cultural practices of warm- and cool-season turfgrasses need to be modified for the successful performance of these facilities.

This study had as its objective to evaluate the influence of nitrogen and potassium on turfgrasses subjected to simulated sports activity when grown on a sand rootzone.

'Manhattan II' perennial ryegrass *(Lolium perenne* L.) and 'Santa Ana' hybrid bermudagrass *(Cynodon dactylon x* C. *trarwvaalensis* var. Santa Ana) were separately established on the UCR sand-filled basin model sports field. The particle size distribution of the media is given in Table 1. On mature turf, nitrogen and potassium as fertilizer nutrients were applied to the study area and the grasses then evaluated for turfgrass traffic tolerance. Nitrogen was applied as ammonium sulfate (21-O-O) at 1 .O lb per 1000 sq ft. Potassium was applied as potassium sulfate (O-0-50) at 1.0 lb per 1000 sq ft. The third treatment evaluated was the combination of nitrogen and potassium at 1.0 lb per 1000 sq ft each. Fertilizer treatments were made monthly beginning May 16, 1990, through April 12, 1991. The study included an untreated control.

Table 1. Sand content of UCR model sports turf plot.

Description	Size (mm)	Weight (%)	
Very coarse sand	1.00 - 2.00	2.5	
Coarse sand	0.50 - 1.00	22.0	
Medium sand	0.25 - 0.50	64.5	96.0
Fine sand	0.05 - 0.25	9.5	
Very fine sand	<0.05	1.5	

The turfgrasses were submitted to simulated sports traffic to evaluate the effects of nitrogen and potassium nutrients. From July 5, 1990 to May 8, 1991, a Brinkman Traffic Simulator (BTS) was used to apply two to three football game equivalents per week (1). Visual injury ratings were made on a regular basis throughout the study.

Root samples were taken with a 3-in. (7.62-cm) diameter sampler at the end of each experiment. The samples were sliced into segments 0 to 2 in. (O-5 cm) and 2 to 8 in. (5-20 cm). The sand was washed from the roots and the roots dried and weighed.

Changes in the impact absorption characteristics were measured with a Clegg Impact Tester with a 5-lb (2.25-kg) missile and expressed as G_{max}, which represents the peak decrease in acceleration of the falling missile as it impacts the turf surface.

Traction was measured with a 93-lb (42-kg) plate with football type cleats dropped into the turf. The torque required to turn the plate was recorded with a torque wrench calibrated in meter-kilograms.

RESULTS

Experiment 1: Perennial Ryegrass Throughout the perennial ryegrass study, the treatments containing nitrogen had significantly higher visual ratings indicating better traffic tolerance (Table 2). Visual ratings of potassium-alone treatments were not different from the untreated control. Potassium. did not appear to improve the recovery rate as observed in July 1991, which was 2 months after the final traffic treatment.

Table 2. Perennial ryegrass traffic injury visual rating: 1 = bare ground; 9 = no injury.

Treatment	8/26/90	5/15/91	7/10/91
Nitrogen 1 .O#/M	7.25	7.25	8.25
Potassium 1 .O#IM	6.25	2.75	4.25
N + K l.O+l.O#/M	7.75	7.75	8.25
Control	5.75	2.50	4.00
LSD	(72)	(.93)	(93)

Traffic significantly reduced the perennial ryegrass roots located 2 to 8 in. below the surface. With no traffic, the perennial ryegrass surface roots (O-2 in.) treated with nitrogen were significantly less than those with potassium alone, but neither was significantly different than the control (Table 3). Under traf-

Table 3. Peremrial ryegrass root density: grams oven dry weight per 3-m. diameter sample.

	0 to 2 inches		2 to 8 inches	
Treatment	Traffic	No Traffic	Traffic	No Traffic
Nitrogen 1 .O#/M	0.90	0.96	0.63	0.74
Potassium 1 .O#/M	1.05	1.26	0.93	0.97
N + K l.O+l.O#/M	0.88	1.07	0.72	0.95
Control	1.04	1.16	0.76	1.06
LSD	0.25		0.22	

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fic, the deeper roots with nitrogen and with potassium were different from each other, but not from the control. Under no traffic, nitrogen significantly reduced the deeper roots.

Measured on two dates in the perennial ryegrass, the surface of the traffic treatments was significantly harder than the treatments not receiving traffic (Table 4). Nutrient treatments made no significant difference in the change in impact absorption. Note that higher values indicate a harder surface.

Perennial ryegrass traction in January 1991 was significantly higher in the nitrogen-plus-potassium treatment under traffic comparison to the two nutrients alone (Table 5). By July, the nitrogen-plus-potassium treatment was significantly greater under traffic than any other treatment.

Experiment II: Hvbrid Bermudagra. Potassium tended to increase the traffic tolerance of the hybrid bermudagrass in comparison to nitrogen-only treatments (Table 6). In May 1991, nitrogen alone and the control showed significantly more injury than potassium alone and with nitrogen. None of the other treatments were significantly different.

Hybrid bermudagrass surface roots (0-2 in.) were not significantly changed by any treatments (Table 7); however, nitrogen treatments significantly reduced the deeper root density. Potassium encouraged, deeper rooting under no traffic on sand.

Traffic significantly increased the hardness of the hybrid bermudagrass study (Table 8); however, there was no significant difference between nutrient treatments . Note that higher values indicate a harder surface.

Table 4. Perennial tyegrass impact absorption with and without traffic as measured by Clegg Impact Test: G_{max}.

Treatment	1/23/91 Traffic	1/23/91 No Traffic	7/12/91 Traffic	7/12/91 No Traffic
Nitrogen 1 .O#/M	33.95	23.60	35.00	16.83
Potassium 1 .O#/M	33.20	27.65	35.92	24.00
N + K l.O+l.O#/M	37.75	21.05	36.58	18.34
Control	31.90	24.75	32.00	23.08
LSD	7.19		6.81	

Table 5. Perennial ryegrass traction: meter-kilograms torque with 93-lb (42-kg) cleated traction plate.

Treatment	1/23/91 Traffic	1/23/91 No Traffic	7/12/91 Traffic	7/12/91 No Traffic
Nitrogen 1 .O#'/M	3.30	3.90	4.38	4.40
Potassium 1 .O#/M	3.23	4.43	3.55	5.00
N + K l.O+l.O#/M	4.43	3.80	5.05	4.45
Control	3.55	4.35	3.45	5.05
LSD	.95		.67	

Table 6. Hybrid bermudagrass traffic injury visual rating: 1 = bare ground; 9 = no injury.

Treatment	8/26/90	5/15/91	7/10/91
Nitrogen 1 .O#/M	3.75	4.00	6.50
Potassium 1 .O#/M	6.00	6.00	7.00
N + K 1.0+1.0/M	6.25	6.00	7.00
Control	5.75	4.25	6.00
LSD	2.57	1.42	1.33

Table 7. Hybrid bermudagrass root density: grams oven dry weight per 3-m diameter sample.

Treatment	0 to 2 inches Traffic	0 to 2 inches No Trafftc	2 to 8 inches Trafftc	2 to 8 inches No Traffic
Nitrogen 1 .O#N	1.10	1.17	1.13	1.41
Potassium 1 .O#/M	1.22	1.25	1.33	1.71
N + K l.O+l.O#/M	1.05	1.13	1.12	1.23
Control	1.27	1.39	1.45	1.54
LSD	.26		.30	

Table 8. Hybrid bermudagrass hardness with and without traffic as measured by the Clegg Impact Test: G_{max}.

Treatment	1123191 Traffic	1123191 No Traffic	7/12/91 Traffic	7/12/91 No Traffic
Nitrogen 1 .O#/M	26.55	5.85	31.28	11.90
Potassium 1 .O#/M	27.40	5.25	32.08	13.15
N + K l.O+l.O#/M	27.15	6.95	32.33	15.68
Control	26.35	5.85	30.68	12.43
LSD	4.52		5.31	

Table 9. Hybrid bermudagrass traction: meter-kilograms torque with 93-lb (42-kg) cleated traction plate.

Treatment	1123191 Traffic	1123191 No Traffic	7/12/91 Traffic	7/12/91 No Traffic
Nitrogen 1 .O#/M	2.73	3.4s	4.45	5.35
Potassium 1 .O#/M	2.70	3.25	4.60	5.23
N + K l.O+l.O#/M	2.68	3.30	4.55	5.80
Control	2.70	2.90	4.55	5.68
LSD	.39		.67	

Traction was significantly reduced by traffic in hybrid bermudagrass (Table 9). In January, under no traffic, nitrogen alone increased traction significantly.

DISCUSSION

As sand rootzone sports field construction has become “state-of-the-art,” it has brought a challenge to the sports turf manager to adapt to the new environment . Nutritionof turfgrass on sand has become important in maximizing tolerance to sports traffic.

Perennial ryegrass on a sand rootzone responded to nitrogen and potassium with nitrogen increasing the traffic tolerance of the topgrowth at the expense of root growth. Even though the turf appearance and the surface roots (O-2 in.) did not show big differences with the addition of potassium, there was a significant improvement in the deeper roots when potassium was applied with the nitrogen.

Traction as an approximation of footing was improved significantly with the combination of nitrogen plus potassium. This suggests that nitrogen with potassium increased the recovery capability of the perennial ryegrass turf after traffic.

Hybrid bermudagrass traffic tolerance increased as potassium was added to nitrogen, yet there was little change in root mass under traffic. The application of nitrogen on bermudagrass under traffic did not adversely affect the roots, allowing the turf to retain its full ability to recovery from injury.

Perennial ryegrass and hybrid bermudagrass responded differently, but when either grass on sand rootzone is under traffic, there is benefit to applying potassium with the nitrogen treatments.

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Events Traffic on Sports Field: Protection and Recovery

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The sports field offers a large open space that is attractive to a wide variety of uses. School carnivals; commencement, religious, and political rallies; dances; and concerts satisfy community needs as well as generate revenue.

The sports field takes considerable abuse before, during, and after an event, which usually lasts from 2 to 4 days. Before the event, the field is usually covered in some manner and the traffic consists of forklifts and trucks as well as foot-traffic during staging setup, chair placement, and perhaps, rehearsal. During the event, the traffic becomes the walking, running, and dancing of hundreds or thousands of people. After the event, the trucks and forklifts are back.

Few guidelines exist as to what should be done to protect the turf and encourage recovery from the inevitable injury. Turf managers have used various methods for field protection, some more successful than others.

THE STUDY

A study was conducted at the University of California, Riverside, to evaluate the ability of field covers to protect turf under events-type traffic and the effects of post-event syringing for turf recovery. In the first experiment, perennial ryegrass turf was covered and received traffic for 2 days. In the second test, 4 days of cover and traffic was evaluated.

The field covers were geotextile and Enkamat. Geotextile is spun polyester cloth that is lightweight and incredibly resistant to puncturing and tearing. Enkamat is a multilayered series of polymer coils that resemble bedsprings. Both materials compress under weight while distributing that weight and allowing air to the grass. Plywood has been used with and without the fabrics to reduce ruts, particularly where heavy equipment is operated in setting up the event.

Syringing is a very light application of water to modify the micro-climate in the plant canopy. It increases humidity and decreases surface temperature by evaporation.

The field cover treatments in each experiment were: (i) one layer of geotextile under 3/4-in. plywood; *(ii)* two layers of geotextile under plywood; *(iii)*one layer of geotextile plus Enkamat under plywood; *(iv)* plywood alone; and (v) control (no cover). Traffic treatment consisted of driving a 14,000 lb-forklift over the plots 20 times per day of each experimental period (2 days in Experiment 1 and 4 days in Experiment 2).

The subtreatments in each experiment consisted of: *(i)* syringing one-half of each plot immediately after removing the field covers, at 1.5 hours after removal and 3.0 hours after removal; and *(ii)* no syringing. Syringing was performed with a medium spray from a hand-held hose nozzle once over the designated area with the operator walking at 1 to 2 m.p.h.

Before syringing, all plots were slit-aerified immediately after removing the field covers and all received irrigation 4 hours after field cover removal. Aeration by slitting or spiking is quick with minimum cleanup. Slitting consists of punching holes with flat, triangle blades mounted on a drum. A spiker uses solid, round tines. Either unit will help open the turf surface improving the effectiveness of irrigation after the compaction of an event on the field. One week after the field covers were removed from each experi-

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ment, data collection was discontinued, and the experiment was terminated. Any technique to enhance turf recovery from events traffic would be required to show dramatic improvement within 1 week, or it would not be considered valuable to the sports turf manager.

In turfgrass research, statistics are used to account for the variability in soil, water, turfgrasses, and that certain bit of unpredictability in the way plants grow. For confidence in the research, experiments are designed with treatments randomized and replicated to assess only the results that are reproducible. After the statistical analyses are made, the researcher is aware of which results are significantly different from what would result by chance. When the word “significant” is used in reporting research data, the researcher is making a strong statement indicating that there is at least a 95% probability that the same results can be achieved again. The statement “not significant” means that there really is no difference between treatments, and treatment differences in the data could be just by chance.

RESULTS

Experiment 1: Two-DayCover. At the removal of the field covers, all plots showed considerable distress, with the turf surface in the control plots destroyed. The turf under the plywood alone showed injury from the lateral movement of the plywood under the forklift. The turf was bruised and torn in a twisted pattern.

With syringing, the best treatment was plywood with one layer of geotextile (Table 1). Even though this field cover was not significantly better than two layers of geotextile and geotextile and Enkamat, it was significantly better than plywood alone and the uncovered control.

With syringing, all treatments with field covers under plywood were better than plywood alone or the uncovered control. Also, the plywood without covers had better appearance than the control, as would be expected. There appeared to be an improvement in turf recovery after 7 days with syringing compared to no syringing.

Table 1. Two-day duration: Turf score* 7 days after removal of covers

Treatment	Syringed**	Nonsyringed**
2-geotex + plywood	8.0 A	6.3 B C
1-geotex + plywood	7.5 AB	6.5 ABC
1-geotex + Enka + ply	7.5 AB	6.0 BC
Plywood	5.8 C	5.8 C
Control	1.0 D	1.0 D

* Turf score: 1 = no recovery; 9 = complete recovery.
** Data in columns followed by same letter are not significantly different.

Extmiment 2: Four-Dav Cover. As expected at the removal of the field covers after 4 days of cover and forklift traffic, the plots were even more distressed than in the 2-day plots.

Without syringing, all of the covered surfaces were significantly better than the control, though none of the turf in any of the plots was acceptable after 7 days (Table 2).

The effects of syringing were very dramatic in this experiment. Seven days after the covers were removed, only the syringed plots had acceptable turf. The plots covered with geotextile and plywood alone were significantly better than the geotextile/Enkamat which was better than the control. The turf under the geotextile/Enkamat plot in this experiment was more bruised and torn than that under the plywood alone.

Table 2. Four-day duration: Turf score* 7 days after removal of covers.

Treatment	Syringed**	Nonsyringed**
2-geotex + plywood	6.3 A	3.5 A
I-geotex + plywood	5.8 A	3.3 A
Plywood	5.8 A	3.0 A
I-geotex + Enka + ply	3.5 B	2.8 A
Control	1.0 CD	1.0 B

* Turf score: 1 = no recovery; 9 = complete recovery.
** Data in columns followed by same letter are not significantly different.

DISCUSSION

For protection of a sports field from traffic created by events, of the treatments studied, a combination of geotextile and plywood offered the best protection. Even with slitting, syringing the turf immediately after removing the cover can mean the difference in having turf a week later versus not having turf regardless of the field cover type.

Syringing after cover removal is not impractical. It can be done. It does require organization in getting hoses, quick couples, and nozzles ready prior to the event and then used immediately following cover removal.

The sports turf manager cannot rely on using the irrigation system for syringing. Broken sprinklers are almost inevitable with equipment around a sports field, regardless of the care in marking them. Organizing the removal of the chairs,. staging, sound equipment, and field covers to conform to the coverage of each irrigation station is more difficult than putting hoses in the hands of people with instructions to lightly sprinkler everything that is green. This is one of those times for the skills of the craftsman to tend to detail.

[Field cover materials supplied by Covemaster, Inc.]

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.

Late-Season Color Retention of Bermudagrass

Late-season nitrogen applications have been us to enhance late fall color and growth of warm-season turfgrasses. Often, at those times, nitrogen is applied in association with potassium, with the potassium intended to increase winter hardiness, especially in areas with quite low and potentially damaging winter low temperatures. The objectives of this study were to measure turfgrass responses to late-growing season applications of nitrogen and potassium to Tifgreen bermudagrass. It was found that potassium rates of 1 or 2 lbs per 1000 sq ft gave no changes in bermudagrass color; however, approximately the same rates of nitrogen produced both color retention in the fall and earlier greenup in the spring, with the response being linear by fertilizer rate. Improved fall color lasted from 3 to 6 weeks, depending on the year of observation. At no time during this study was there a visible sign of turfgrass injury or winterkill for any treatment. Following one winter with severely low winter temperatures (1989), the only observed effect was a somewhat slower transition from dormancy to color and active growth in the spring of 1990. The authors clearly point out that late-season nitrogen fertilization may result in problems such as a possible increase in nitrogen leaching, a possible increase in winter weeds, and a possible increase in the severity of certain diseases so that costs and benefits of late-season color retention must be carefully considered. Although this work was done in Mississippi, the principle of late-season nitrogen application to enhance color retention in warm-season turfgrasses has been used as a management practice in California, when site-specific conditions and needs required it.

See: Goatley, J.M., V. Maddox, D.J. Lang, and K.K. Crouse. 1994. 'Tifgreen' bermudagrass response to late-season application of nitrogen and potassium. Agronomy Journal 86(1):7-10. (VAG, 1994).

WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in their original labeled containers in a locked cabinet or shed, away from food or feeds and out of the reach of children, unauthorized persons, pets and livestock. .

Recommendations are based on the best information currently available, and treatments based on them should not leave residues exceeding the tolerance established for any particular chemical. Confine chemicals to the area being treated. THE GROWER IS LEGALLY RESPONSIBLE for residues on his crops as well as for problems caused by drift from his property to other properties or crops.

Consult your County Agricultural Commissioner for correct methods of disposing of leftover spray material and empty containers. **Never burn pesticide containers.**

PHYTOTOXICITY: Certain chemicals may cause plant injury if used at the wrong stage of plant development or when temperatures are too high. Injury may also result from excessive amounts of the wrong formulation or from mixing incompatible materials. Inert ingredients, such as wetters, spreaders, emulsifiers, diluents and solvents, can cause plant injury. Since formulations are often changed by manufacturers, it is possible that plant injury may occur, even though no injury was noted in previous seasons.

NOTE: Progress reports give experimental data that should not be considered as recommendations for use. Until the products and the uses given appear on a registered pesticide label or other legal, supplementary direction for use, it is illegal to use the chemicals as described.

CALIFORNIA TURFGRASS CULTURE EDITORIAL COMMITTEE

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