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Topdressing Compost on Bermudagrass: Its Effect on Turf Quality and Weeds

Pamela Geisel[1], Michelle Le Strange[2], and Deborah Silva[3]

Introduction

California's Integrated Waste Management Act (AB 939) mandates a 50% reduction in solid waste that each county and city send to landfills by the end of 2000, using 1990 as the base year, and further specifies that the solid waste reduction be accomplished by (i) composting, (ii) recycling, and (iii) source reduction. Other solid waste reduction methods, such as incineration, are limited to 10% of the 50% reduction requirement. To comply with AB 939, municipalities all across the state have implemented green waste pick-up programs that have yielded tons of compost. Possible beneficial uses of this compost could include topdressing turf areas on school grounds, golf courses, community recreation fields, and parks (1, 3, 4, 6, 8). The objective of this three-year field study was to compare compost topdressing with conventional fertilizer applications, determine optimum depth and timing of compost applications, and evaluate the benefits and risks of compost topdressing from cultural and financial perspectives.

Methods and Materials

Field studies were conducted from October 1994 to December 1997 at California State University, Fresno, on a well-established common bermudagrass (*Cynodon dactylon*) lawn used occasionally as a practice band field. The soil was Hanford sandy loam. Historically, the site was not fertilized or maintained during the winter months. Typical turf maintenance practices during the active growing season (April - October) included mowing 2x/mo and sprinkler irrigation 3x/wk. The site was infested throughout with two weeds, annual bluegrass (*Poa annua*) and crabgrass (*Digitaria sanguinalis*).

Plots were 10 ft x 18 ft arranged in a randomized complete block design with 8 replications/treatment. Fertilizer and steer manure (SM) treatments were applied to yield 4 lb actual nitrogen (N)/ 1000 ft^2/yr, a typical N fertilization recommendation for minimal maintenance turfgrass (9). Single applications of SM and slow-release fertilizer (Once, 34-0-7, Sierra Ag Chemical Co.) were made in October 1994, 1995, and 1996. Ammonium sulfate applications (21-0-0) were made quarterly each year in October, April, July, and September.

The compost was derived from 50% green waste and 50% biosolids. Laboratory analysis yielded 30% organic matter (OM), 1.4% N, 0.99% P, 0.66% K, 0.14% ppm Na, and 60.1% ash. Single compost applications were made yearly in October at depths of 1/8, 1/4, 1/2 and 1 inch. Assuming a 15% N release rate, it was estimated that the 1, 1/2, 1/4, and 1/8 inch compost topdressing treatments supplied 8 lb, 4 lb, 2 lb, and 1 lb actual N/1000 ft^2, respectively. Compost treatments included multiple applications to equal a total of 1 inch compost/yr (8 lb actual N). Either 1/2 inch was applied 2x/yr in October and July or 1/4 inch was applied 4x/yr in October, April, July, and September (Table 1). Costs were estimated as reported in Table 1.

Turfgrass quality and color were evaluated visually on a rating scale that ranged from 1 to 9 with 9 being most desirable. A rating of 5 was considered marginally acceptable (2, 5). Turf quality included stand uniformity, density, color, presence/ absence of weeds, and overall visual appeal. Onset of dormancy in late fall and shifts in weed populations (% surface area occupied by weeds) were observed and recorded.

Total N content in clippings and soil, soil OM, thatch development and clipping yield were measured. Grass clippings were collected from each plot in July 1996 and weighed (lb dry matter/acre) to determine yield (7).

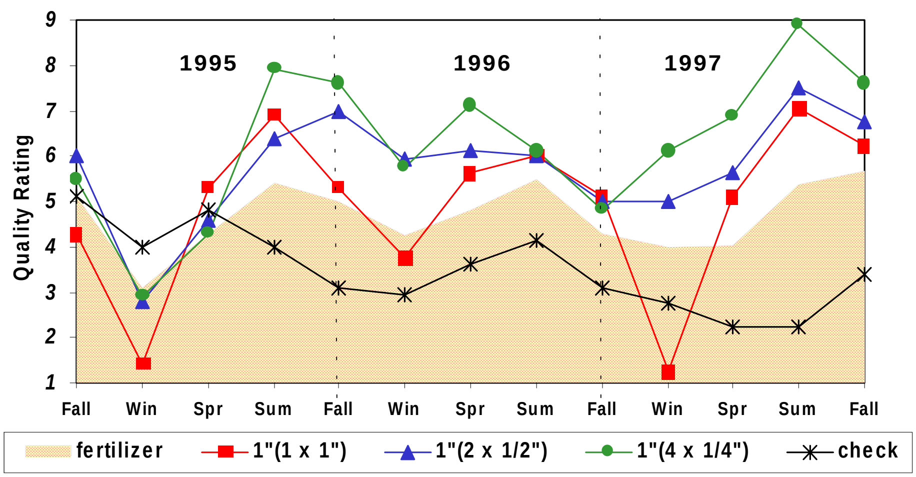
An analysis of variance (ANOVA) was conducted with significance determined by the least significant difference (LSD) and variation in the study determined by calculating the coefficient of variation (CV%).

Results and Discussion

Turf Quality. Turf quality is reported in Table 2 and Figure 1. The highest turf quality was observed in plots receiving the 1/4

[1]Environmental Horticulture Advisor, Fresno County, University of California Cooperative Extension.
[2]Farm Advisor, Tulare and Kings Counties, University of California Cooperative Extension.
[3]Technical Editor and Writer (freelance), Riverside, CA.

Figure 1. Compost effect on turf quality.



Rating scale was 1 to 9 with 1= worst, 5 = marginally acceptable, and 9 = best.

inch compost application quarterly (Fig. 1); however, results from the 1/8 and 1/4 inch compost topdressing treatments were not significantly different from the fertilizer and SM treatments (Table 2). Compost topdressings of 1/2 and 1 inch buried the turfgrass, which lowered quality for several months until the turf recovered. These rates were determined to be too much to apply at one time. Untreated check plots averaged a 3.6 quality rating over all seasons. At each rating date, they were visibly thinner, less green in color, and lower in overall appeal than treated plots, with the following exceptions: In November 1994, one month after treatments began, there were no significant differences among all treatments. In November 1995, the ammonium sulfate and 1 inch compost treatments were significantly lower in overall quality and no different from the check, respectively.

Turf Color and Dormancy. Turf color and dormancy are reported in Table 3 and Figure 2. The three-year average over all seasons revealed that all treated plots were greener in color than the untreated check plots, and the onset of winter dormancy was delayed. The untreated check plots ranged from a winter low rating of 1.9 to a summer high of 4.3, with a three-year mean of 2.9. Ammonium sulfate and slow-release fertilizer treatments ranged from a winter low rating of 2.1 to a high of 7.4 and an overall three-year mean of 3.9 and 4.3, respectively, both below the marginally acceptable rate of 5.0.

The 1/8 inch compost and SM treatments closely resembled the fertilizer applications. As more compost was topdressed (1/4, 1/2, and 1 inch treatments), turf color improved even more during all growth seasons, and the onset of dormancy was delayed. Spring green-up was enhanced by the 1/2 and 1 inch compost treatments. All experimental treatments did green up more quickly than the check. The onset of dormancy was delayed, presumably due to more available N in the compost, and, maybe, heat absorption due to the darker color of the compost.

One objective had been to clarify the relationship between %N in clippings and the turf's visual quality color ratings. While the relationship was not clear-cut, the general trend was that the higher the %N in the clippings, the better the visual color ratings; however, in July the best color ratings were found in the 1/4 inch compost treatment applied 4x/yr, not the 1/2 inch treatment applied 2x/yr, even though the latter yielded the highest %N in clippings (data not presented).

Weed Populations. Weed populations are reported in Table 4. Annually, two weed population peaks were observed, both associated with the winter and summer peaks of *P. annua* and *Digitaria sanguinalis*, respectively. Weed populations were lowest in all plots in November because, at this time of year which was between the summer and winter annual weed growth

Table 1. Compost and fertilizer treatments and costs.

Treatments	(per 1000 ft^2/yr) Pounds Product	Cost of Material	Pounds N	Cost of 1 lb N	Cost of Application[z]	Total Cost
Check						
Steer manure[y]						
-bag	1555	$27.75	4	$6.94	$2.34	$30.09
-bulk	1555	$12.25	4	$3.06	$2.34	$14.59
Slow release fertilizer (Once®)	12	$10.08	4	$2.52	$8.00	$18.08
Ammonium sulfate	20	$ 2.80	4	$ .70	$32.00 ($8.00 x 4 applications/yr)	$34.80
Earthwise Organics Nature's Yield Compost[x]						
1/8"	555	$ 6.52	1	$6.52	$ .81	$ 7.17
1/4"	1110	$13.04	2	"	$1.65	$14.57
1/2"	2220	$26.08	4	"	$3.30	$29.15
1"	4440	$52.17	8	"	$6.60	$58.30
1/2" x 2 applications	4440	$52.17	8	"	$6.60 ($3.30 x 2)	$58.30
1/4" x 4 applications	4440	$52.17	8	"	$6.60 ($1.65 x 4)	$58.30

[z]Application costs were determined by surveying landscape applicators and averaging their price quotes, which were $3.00 per ton for compost and manure with a minimum tonnage purchase and $8.00 per 1000-square feet for fertilizers. These figures do not include overhead and profit expenses incurred by private application companies.
[y]Steer manure could be purchased by the bag or in bulk by the cubic yard. It was 0.86% N and we assumed a 30% release rate.
[x]Compost cost was $23.50 per ton.

Table 2. Compost effect on turf quality[y].

	Check[z]	SM	SRF	AS	1/8"	1/4"	1/2"	1"	1/4"x 4	1/2"x 2	*LSD .05*	*CV %*
Nov-94	5.1	4.9	5.1	5.4	4.8	5.4	6.0	4.3	5.5	6.0	*1.1*	*20.1*
May-95	4.0	5.1	5.3	5.8	5.1	6.1	5.9	6.9	7.9	6.4	*0.9*	*15.8*
July	2.9	4.0	4.6	4.0	3.9	4.6	5.5	6.2	7.1	5.8	*0.9*	*17.8*
Aug	3.1	5.0	4.1	5.8	4.0	4.8	5.0	5.3	7.6	7.0	*0.8*	*15.6*
Nov	2.9	4.4	4.4	3.9	4.1	4.7	6.5	3.8	5.8	5.9	*1.1*	*22.7*
May-96	3.6	4.9	4.5	5.1	4.6	5.0	5.9	5.6	7.1	6.1	*0.7*	*12.5*
July	4.3	5.0	5.4	6.1	5.0	5.1	5.4	5.8	7.0	3.3	*0.6*	*11.9*
Sept	5.9	5.5	5.9	5.4	6.0	5.5	5.9	5.0	4.9	4.9	*0.9*	*16.6*
Nov	2.8	4.4	3.9	3.8	3.8	4.3	3.4	1.3	6.1	5.0	*0.9*	*24.4*
May-97	2.3	5.5	6.9	3.8	3.8	4.6	5.2	7.1	8.9	7.5	*0.8*	*18.5*
July	2.8	5.3	6.3	4.4	4.3	4.1	4.1	5.5	6.8	5.8	*0.8*	*15.6*
Sept	3.4	6.0	5.1	5.9	4.1	4.9	4.6	6.3	7.6	6.8	*0.8*	*15.1*
Average	**3.6**	**5.0**	**5.1**	**4.9**	**4.4**	**4.9**	**5.3**	**5.2**	**6.9**	**5.9**		

Table 3. Compost effect on turf color[x].

	Check[z]	SM	SRF	AS	1/8"	1/4"	1/2"	1"	1/4"x 4	1/2"x 2	*LSD .05*	*CV %*
Nov	4.3	5.1	4.3	4.1	5.1	5.4	6.8	7.4	6.1	6.8	*0.9*	*17.0*
Mar-95	3.0	4.3	3.3	3.4	4.0	4.3	5.0	5.6	4.4	5.1	*0.7*	*17.6*
May	3.1	5.4	4.9	5.8	4.8	6.3	7.1	7.6	8.4	7.0	*0.8*	*13.7*
Dec	2.4	4.8	3.8	3.0	3.6	5.9	7.8	8.0	6.9	8.0	*0.4*	*8.3*
Mar-96	1.9	3.4	2.3	2.3	2.8	3.1	4.0	4.5	3.6	4.3	*0.6*	*17.5*
May	3.6	5.3	5.4	5.1	4.3	5.0	5.8	6.4	7.1	5.8	*0.7*	*12.7*
Nov	1.9	4.9	2.9	3.1	3.3	4.1	4.9	4.9	6.5	7.6	*0.9*	*21.3*
Mar-97	3.4	4.5	6.4	5.5	4.0	3.9	4.5	7.6	8.0	7.0	*0.6*	*17.5*
May	3.3	6.5	7.4	3.8	4.1	4.8	5.4	7.6	7.9	7.6	*0.7*	*12.7*
Dec	2.0	3.8	2.1	3.0	2.0	2.4	3.0	4.5	5.0	4.8	*0.4*	*12.5*
Average	**2.9**	**4.8**	**4.3**	**3.9**	**3.8**	**4.5**	**5.4**	**6.4**	**6.4**	**6.4**		

Table 4. Compost effect on percent weeds[w].

	Check[z]	SM	SRF	AS	1/8"	1/4"	1/2"	1"	1/4"x 4	1/2"x 2	*LSD .05*	*CV %*
Nov	33	26	64	35	53	44	29	0	40	23	*15*	*45*
Mar-95	66	69	74	67	79	71	66	35	77	57	*16*	*24*
July	43	45	40	21	40	34	38	46	16	38	*14*	*38*
Aug	67	43	47	28	58	46	39	41	4	13	*16*	*43*
Nov	40	25	22	28	25	19	6	10	24	13	*18*	*84*
Mar-96	72	68	86	58	89	65	36	24	23	27	*14*	*26*
May	49	48	41	40	44	41	30	30	10	25	*14*	*38*
Aug	72	61	44	63	71	79	85	72	14	28	*15*	*26*
Nov	11	9	9	12	23	9	6	4	7	8	*7*	*74*
Mar-97	77	72	86	83	81	83	39	6	66	24	*17*	*28*
June	83	76	6	58	64	54	64	21	5	32	*16*	*35*
Aug	78	23	21	62	77	70	85	45	10	49	*14*	*27*
Average	**57**	**47**	**45**	**46**	**59**	**51**	**44**	**28**	**25**	**28**		

[z]Treatments: check = untreated, SM = steer manure, SRF = slow release fertilizer, AS = ammonium sulfate, compost applications in inches.
[y]Visual rating scale for quality, where 1 = worst, 9 = best, and 5 = marginally acceptable.
[x]Visual rating scale for color, where 1 = least green and 9 = most green.
[w]Percent surface area of the plot (0-100%) occupied by weeds.

cycles, crabgrass was dying out and annual bluegrass was just emerging. During the three-year experimental period, all treatments, except the three 1-inch compost plots, had an average of 44-59% weeds. The 1-inch compost applications averaged 25 to 28% weeds.

Winter Weeds. The 1/2 and 1 inch compost topdressed plots averaged lower *P. annua* populations compared to all other treatments, but very poor turf quality during the winter months (Table 2). This result may be explained by the mulching effect of the excess compost that covered weed seeds, reducing or delaying germination. *P. annua* populations were highest in the check, fertilizer, and 1/8 and 1/4 inch compost treatments (see March ratings in Table 4). The 1/4 inch compost treatment failed to reduce *P. annua* in winter because there was no mulching effect from this treatment, unlike the heavier compost applications.

Summer Weeds. The 4 applications of 1/4 inch compost averaged the lowest in crabgrass weed populations in the summer (Table 4). This light, frequent topdressing nourished the bermudagrass turf regularly and gave it a competitive advantage over the crabgrass. Although all plots were crabgrass-infested, all fertilizer-treated plots averaged significantly lower percentages of summer weeds than check plots, presumably because of the competitive bermudagrass growth response to fertilizer treatments.

Thatch and Organic Matter in Soil Samples. The thatch layer, which consists of compressed green tissue and older tissue (stems, rhizomes and stolons), was easy to see and measure because of the color difference between it and the darker OM layer directly below it. No significant differences occurred in thatch development for all treatments.

Yield of Grass Clippings. The highest grass clippings yield was observed with the 1/4 inch compost treatment applied quarterly (Table 5). Clipping yields associated with slow-release fertilizer, ammonium sulfate, 1/2 inch compost applied 2x/yr, and 1 inch compost applied once/yr were not significantly different from each other but were all significantly less than the yields from the 1/4 inch compost topdressing treatment applied

Table 5. Compost effect on grass clipping yield.

	Grass yield lbs DM/acre[z]
Check	240.0 f
Steer manure	434.3 de
Slow release fertilizer	590.9 bc
Ammonium sulfate	508.8 cd
1/8 inch	270.4 f
1/4 inch	360.9 ef
1/2 inch	320.5 ef
1 inch	703.6 bc
1/2 inch x 2	701.3 bc
1/4 inch x 4	1115.0 a
LSD .05	144.0
CV %	27.5

[z]Average of June and July 1996.
Mean comparisons among treatments was by LSD (P<0.05).

quarterly (Table 5). These results were somewhat unexpected. One explanation may be that the 1/4 inch compost applied 4x/yr was least disruptive to bermudagrass growth because turf crowns and foliage were not buried by this compost layer. Alternatively, the sustained N release from the quarterly, fresh compost applications may favor consistent and vigorous growth of bermudagrass throughout the season, yielding the highest clippings.

A high clipping yield associated with rapid growth is not necessarily desirable. Rather, a sustained rate of moderate plant growth is preferred. The plots topdressed with 1/4 inch compost quarterly would have benefitted from a more frequent than weekly mowing schedule because of their rapid growth rate. The very high clipping yield observed in these plots may be a negative characteristic, although these plots performed with consistently high quality ratings throughout the year.

Conclusions

Compost topdressing applied on municipal bermudagrass turfgrass sites can have cultural benefits. Overall, consistently higher turfgrass quality ratings and lower summer weed populations of crabgrass were found when 1/4 inch compost topdressings were applied 4x/yr (October, April, June, and August). However, a high clipping yield was observed with this treatment. In future research, it would be prudent to test if a 1/4 inch compost topdressing applied 2 or 3x/yr would yield the same positive cultural benefits, including (1) increased turf quality ratings and (2) reduced summer weed infestation but, in addition, (3) reduced clipping yields, and (4) reduced application costs. Single compost applications of 1/8, 1/4, and 1/2 inch were better than none, providing a small increase in quality and color throughout the year compared to the check, but were insufficient to improve turf performance to a higher standard. One inch applied at one time is not recommended because it resulted in a very low quality turf for several months until the organic matter that smothered the turf filtered into the soil profile.

In terms of application and material costs, compost is significantly more expensive per lb N than synthetic fertilizers but comparable to SM. Compost application costs are based on tonnage, rather than the area to be treated. Thus, the cost of application increases significantly as the rate of topdressing increases. However, the environmental benefits associated with landfill reduction, reduction in herbicide applications, and beneficial reuse of community compost may more than offset the increased costs associated with applying compost.

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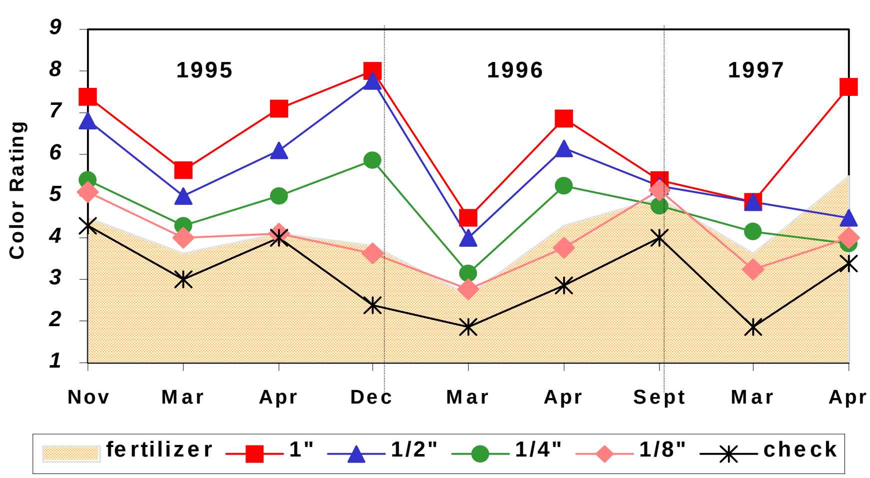
Figure 2. Compost effect on turf color.



Rating scale was 1 to 9 with 1 = least green, 5 = marginally acceptable, and 9 = most green.

Golf Courses and the Environment

Ali Harivandi[1]

The tremendous increase in the game of golf within the past decade has caused a worldwide building boom of new golf courses. As golf courses proliferate, with their large expanses of mowed grass, trees, and shrubs, as well as their considerable non-maintained but plant-covered areas, the general public increasingly asks about potentially negative impacts of golf course management practices. Specifically, the public is questioning the use of pesticides and fertilization on golf courses, as well as the potential for water wastage. In addition to questioning the volume of irrigation water required for these courses, people express concern about the contribution of golf course management practices to pollution of ground and surface waters and to air pollution via maintenance machinery.

Additionally, some claim golf course development has led to deteriorating biosystems, since native (or resident) plants and animals are often replaced with imported, synthetically-managed species. The following list summarizes the most-often cited potentially negative environmental impacts attributed to the development and management of golf courses:

- Wildlife habitat/native plants degradation
- Soil and water contamination (fertilizers, pesticides, fuel, etc.)
- Water use (waste)
- Waste generation
- Urbanization of vicinity

Many organizations in the USA are actively addressing these concerns. Leading the way, the United States Golf Association (USGA) has supported more than 100 studies in environmental research over the past fifteen years. Additionally, the Golf Course Superintendent Association of America (GCSAA), the Professional Lawn Care Association (PLCAA), Sports Turf Manager's Association (STMA), the Turf Producers International (TPI), land grant universities and Cooperative Extension Services, American Society of Agronomy, Crop Science Society of America, and many other Associations are working to better understand environmental issues associated with turfgrass and golf courses.

The current trend in international golf course design is to increase the areas of natural (native/resident) vegetation within a course and to increase wildlife habitat in areas of the course that seldom come into play. This can be accomplished even in areas previously planted to non-native species by reducing or eliminating irrigation, fertilization, pesticide application, and mowing. As they create habitat and sanctuary for wildlife, courses often find it possible to save money and labor that can be better used elsewhere on the course.

One program, noteworthy for its efforts to improve the relationship between golf and the environment, is the Audubon Cooperative Sanctuary (ACSP). This program will assist any golf course interested in enhancing the environment; it currently lists over 500 participating courses in the USA.

As a cooperative effort between USGA and the Audubon International, ACSP's purpose is to enhance and protect wildlife and water resources and to increase public awareness of the positive contributions that golf courses can make to the environment/community. ACSP capitalizes on the fact that most golf courses already provide havens for wildlife through open spaces, greenbelts, and natural sanctuaries. The program also gives golf courses the opportunity to participate in conservation projects.

Elements of the ACSP program include:

- Enhancing wildlife habitats on existing and future golf courses by providing advice to golf course managers about ecologically sound golf course management.
- Encouraging golfers, golf course superintendents, golf officials, and the general public to participate in conservation programs.
- Recognizing golf courses as important open spaces and golf course managers as participants in environmentally responsible projects.
- Educating the public and the golfing community about benefits of golf courses and the important role they can play in uniting the urban and wildlife environment.

Golf course superintendents play an active role in addressing golf course issues as responsibly and professionally as possible. Of prime importance is identifying current management practices that could be made more environmentally friendly. Efforts should be made to:

- Conserve water through efficient irrigation;
- Limit the use of pesticides and synthetic fertilizers as much as possible;
- Increase the area of golf courses devoted to native or naturalized vegetation and wildlife habitat;
- Recycle green waste and grass clippings;
- Recycle/contain hazardous waste;
- Use reclaimed water for irrigation whenever possible.

It is also important for golf course superintendents to learn about the environmental benefits of the plant material, i.e., turfgrass, which they maintain. Such information will allow development of an effective public education program within their community. The following positive aspects of turfgrass may be highlighted:

1. Turfgrasses reduce soil erosion and control dust pollution.
2. Turfgrasses can improve groundwater recharge and quality.
3. Turfgrasses reduce runoff and thereby reduce surface water pollution.
4. Turfgrasses improve the soil ecosystem through continuous deaths and regeneration of roots and other plant tissue.

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[1]Environmental Horticulture Advisor, Alameda, Contra Coast, and Santa Clara Counties, University of California Cooperative Extension.

5. Large expanses of turfgrass (such as those found on a golf course) moderate temperature fluctuations and improve air quality in a community.
6. Turfgrasses effectively revegetate disturbed sites (e.g., building golf courses on abandoned landfills, rock quarries, or mining sites).
7. Irrigating turfed sites (especially golf courses) provides a primary means to reclaim a valuable community waste: treated sewage water (reclaimed water).
8. Turfgrasses provide excellent playing surfaces for various sports (e.g., golf, soccer, etc.), thereby enhancing the physical and mental health of a community.
9. Turfed sites (e.g., golf courses, parks) improve community aesthetics.
10. Turfgrasses used for various sports (especially golf) can contribute significantly to a local economy.

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Sports Turf Management Practices: Mowing and Aeration

Stephen T. Cockerham[1]

Sports field use in our modern society is a function of the attention given to recreation, organized sports, and physical fitness. Two management practices that are regularly performed on heavily used sports fields include mowing and aeration.

Mowing

How tall the grass is permitted to grow and the cutting height can influence the success of the sports field (Table 1). Removal of more than 40% of the top in a single clipping stops root growth. The larger percentage of foliage removed, the longer period of time the root growth remains stopped. The rule of thumb is to mow frequently enough to remove less than 1/3 of the leaf blade at one time to prevent the root growth from being completely stopped.

Mowing reduces rhizome weight and number. Since the rhizomes of many species are important to rejuvenation, spreading, and recovery from injury, anything detrimental can eventually reduce turf density. Tillers behave as if they were individual plants. Severe clipping reduces the number of tillers being initiated, which, as with the rhizomes, eventually decreases the turf density. Bentgrass and bermudagrass will tolerate more severe defoliation than species such as Kentucky bluegrass. Since many of the bents and bermudas have a prostrate growing habit, the low, closely overlapping leaves permit a larger percentage of green foliage to remain after mowing. A relatively high level of photosynthesis continues and root growth is maintained. Over a period of time, root growth may exceed food production from the reduced leaf area and carbohydrate reserves can become depleted. Bermudagrass takes a little longer to go downhill than other species, which allows the sports turf manager to get performance from the grass for a longer period of time.

As might be expected, temperature decidedly influences the impact of mowing on the entire plant. Unclipped Kentucky bluegrass grows better at relatively cool soil temperatures in the mid-60s than at warm (80° F) soil temperatures. Clipped Kentucky bluegrass grows better at the warm temperature than at the cool temperature. The same relationship is true for warm-season grasses, except at slightly higher temperatures. The difference in plant growth between the low soil temperature and the high soil temperature is less with the clipped turf than with the unclipped.

Clipping has more influence on plant growth than soil temperature. Even though root growth is slowed just by clipping, when the temperature increases, root growth dramatically decreases as the mowing height is lowered. This reduction in the root system is an important factor in making warm weather turf management the tricky art that it is. This is why it has long been a rule of thumb for turf managers to raise the mowers as summer approaches and lower them in the fall and spring. Since mowing and mowing height intensifies the effects of temperatures, good irrigation practices become extremely important. With the shortened root system, the turf is actually more susceptible to drought injury than direct heat injury. Low mowing produces denser turf and a faster playing surface but results in a shorter root system. Cool-season grasses kept at a high mowing height then mowed low have better traffic tolerance than grasses kept short, then allowed to grow tall. Mixtures of perennial ryegrass and Kentucky bluegrass perform better under these conditions than Kentucky bluegrass alone. Recovery of bermudagrass subjected to severe wear is essentially the same whether maintained at .25 inch or .75 inch.

Scalping the sports field has a negative effect on the appearance and surface playability. The removal of verdure, (the top growth left after normal mowing), by mowing or traffic, significantly lowers footing. As temperature cools in the late fall, care must be taken to avoid scalping warm season grasses. Color can be removed simply by mowing too low.

[1]Superintendent, Agricultural Operations, University of California, Riverside.

Table 1. Effect of Mowing Height on Turfgrass.

	Mowing Height	
	Lower	Higher
Carbohydrate production	Decrease	Increase
Rooting depth	Decrease	Increase
Blade width	Decrease	Increase
Rhizome/stolon no. & wt.	Decrease	Increase
Rhizome/ stolon internode lgth	Decrease	Increase
Turf vigor	Decrease	Increase
Plant size	Decrease	Increase
Thatch	Decrease	Increase
Puffiness	Decrease	Increase
Durability	Decrease	Increase
Shoot density	Increase	Decrease
Speed	Increase	Decrease

Mowing patterns. The aesthetics of a sports field can be greatly enhanced by creating ribbon or striping mowing patterns. This is often done to give a unique detailing to the field showing all that the management team is proud of the facility.

The pattern is usually created by mowing. Reel mowers with rollers are easiest to pattern. The sports turf manager can increase the intensity of the pattern with brushes or a drag mat.

Field repair and other problems can often be masked by an intense pattern. Cross hatching squares is the easiest to apply. The first passes, at least, must be laid out with string to assure straight lines. Many managers will string out every other pass to be sure the pattern is true.

Aeration

The mechanical pressure applied by sports traffic, especially cleated shoe traffic, results in varying degrees of soil compaction and surface sealing. Compaction on turf occurs primarily in the upper inch of soil or so and shows up in reduced rooting depth when the soil is moist and a reduction in total root growth when the soil is dry. Spring sports traffic causes more soil compaction than fall or winter traffic, possibly because soil moisture tends to be highest in the spring. Traffic also causes sealing by compacting the mat, thatch, and organic matter on compaction-resistant sand rootzone media.

Turfgrass does not grow well in compacted soil or rootzones that have a sealed surface. Sports turf performance is reduced proportionately with increasing compaction. Water moves into the soil very slowly, considerably slower than precipitation from rain or irrigation. Runoff occurs quickly testing the surface drains. Once the soil is wet, it does not drain well and does not allow oxygen exchange. The soil begins to sour from anaerobic activity. The soil and sand has blue colored streaks and pockets and a strong sulfurous odor. A game played on a wet compacted soil will stir up the anaerobic soil and the players complain of feeling ill from the odor. Compaction is the most significant impact of sports traffic and as a result the most important factor to control.

Compaction and sealing that results from sports traffic does not occur uniformly over the entire field. The traffic patterns of each sport are indicators of areas that need attention. Turf damage to game activities is more severe in the compacted and sealed areas.

Field hardness increases with increased compaction. Hardness is a change in the feel of the field for performance and can contribute to injuries. The difference in the surface caused by hard spots affects the play in the running and reaction of a ball.

Sports fields are also subject to other types of traffic. Events usually end up causing compaction. Vehicles moving across the turf to erect stages, seating units, and sound towers are heavy and make a lot of trips. Mowers, sweepers, and sprayers are heavy and even with turf-type tires they cause compaction. As time nears for a big game or opening day, nervous maintenance crews feel the need to do something so there is a trend to double cut, triple cut, and sweep and maybe even roll a time or two. There is enough traffic on a sports field. It is in everyone's interest to protect the turf by thinking twice before walking or driving on the field.

Safety, playability, durability, and aesthetics of the sports field depends upon controlling compaction to achieve surface uniformity. Compaction is controlled by prevention, including not allowing traffic on the field or by building biomass to cushion the soil, and by cultivation of the sealed layers.

Core cultivation is the tilling of the soil to provide aeration without destroying the turf. It is used to (1) relieve soil compaction, (2) relieve surface sealing, (3) aid in thatch control, (4) disrupt undesirable soil layers, (5) prepare for overseeding, (6) enhance fertilizer and pH amendment applications, (7) stimulate turf density by severing stolons and rhizomes, and (8) aid in soil modification.

Soil and sand sports fields should be core cultivated at least in early spring, summer, and fall to reduce localized dry spots and promote turf growth. Severely compacted fields need frequent aeration. On compacted fields that are particularly hard, this may require repeated core cultivation treatments followed by irrigation to eventually get adequate penetration. Practice fields receive more use than game fields and are improved by frequent treatments.

On a sports field, games will be played on a wet soil. The sports turf manager has a couple of tools for use in drying the surface for a game. A drying compound, such as calcined clay works to some extent. Although it is very damaging to the soil structure, and, agronomically, core aerating wet soils is not a generally accepted practice, in an emergency core aerating wet soil can help drying. Muddy soil must be allowed to dry enough to support a vehicle before coring. Coring wet soil will create a tine-sole on the inside of the hole surface and the soil texture will be compromised, which will restrict soil permeability. It will be necessary to core again when the soil dries.

Dragging the field with a steel mat after aeration to breakup the cores and work soil back into the holes will help reduce thatch. Core cultivation may reduce turf quality due to turfgrass crown injury and loss, may increase turf susceptibility to cold injury, and may increase weed encroachment. Overall, there is a general improvement of turf quality with compaction relief, increased infiltration rate in many soils, and opening to the sun to warm the soil.

Core cultivation can be performed with a drum aerator using open and hollow tines or by a vertically operated hollow tine aerator. As the tine is pushed into the turf the soil forces the previous core out of the tine contributing to a cultivation sole or a thin compacted soil layer.

Solid tines are used to shatter the soil below the surface and the process is known as shatter coring. This is most effective on dry soil; wet soil does not shatter, but does compact. Properly used, there is essentially no turf performance difference between the use of the hollow tine core and solid tine core.

Spiking and slicing are effective to increase infiltration and reduce surface crusting. Spikes are nail-like steel tines and slicers are flat steel triangles. The penetration is generally shallow and the openings small, thereby not disturbing the turf surface. Spiking and slicing are quick temporary operations that can be performed just before a game. A tine harrow used in turf is a flexible structure similar to a chain with tines on one side and chain-like on the other. Normally, it is used to scarify with the tines or relieve compaction. Turning it over with the smooth side down it can be used to breakup aeration cores with no damage to the turf. With the tines pulled over the surface, the harrow will disturb the turf considerably.

In conclusion, mowing is the defining action that makes a grass sward into a turf. There is a labor commitment and the equipment, the mowers, is expensive to buy and maintain. How the mowing is done has a significant bearing on the aesthetics and performance of the turf. Of similar importance, aeration by core cultivation relieves soil compaction, relieves surface sealing, and aids in thatch control, to name a few advantages of the process. Both mowing and aeration programs are important primary management practices for all sports turf facilities.

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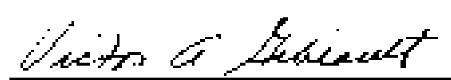

Victor A. Gibeault
Extension Environmental Horticulturist
Bachelor Hall Extension
University of California
Riverside, CA 92521-0124

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