FINAL REPORT

# The Effect of Fall Renovation Treatments on $PM_{10}$ Emissions During Raking of Debris Following Scalping of Common Bermudagrass Fairways Prior to Overseeding

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in cooperation with

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# INTRODUCTION[z]

## The $PM_{10}$ Issue

- In December 1996, Coachella Valley was classified as "serious" nonattainment for fine particulate matter ($PM_{10}$) (aerodynamic diameter of 10 microns or less) in accordance with the Federal Clean Air Act.

- $PM_{10}$ exceedances in the Coachella Valley are primarily due to locally generated sources of fugitive dust and not gaseous emissions.

- The Coachella Valley can be redesignated to "attainment" if, among other requirements, the U.S. EPA determines that the National Ambient Air Quality Standards have been attained for at least three consecutive years. Included in the redesignation is a documented record that best available control measures have been implemented.

## Sources of $PM_{10}$ in the Coachella Valley

- About 49 tons of $PM_{10}$ are emitted on an average day in the Coachella Valley. About 96% is from fugitive dust emissions from wind erosion of disturbed sources, entrained road dust, construction and demolition activity, and farming operations.
  - ≈ 11 tons/day, windblown dust from disturbed desert soils
  - ≈ 16 tons/day, windblown dust from agricultural lands
  - ≈ 1.4 tons/day, mobile sources with heavy-duty diesel trucks accounting for over half
  - ≈ 7 tons/day, mobile sources traveling over entrained paved roads
  - ≈ 5 tons/day, mobile sources traveling over entrained unpaved roads

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[z]Information from Coachella Valley $PM_{10}$ Attainment Redesignation Request and Maintenance Plan. December 1996. South Coast Air Quality Management District.

## $PM_{10}$ Health Effect

- There is a consistent correlation between elevated ambient $PM_{10}$ levels and an associated increase in mortality rates, respiratory infections, number and severity of asthma attacks, and number of hospital admissions.

- Some studies have reported an association between long-term exposure to air pollution dominated by fine particles and increased mortality, a reduction in lifespan, and the possibility of an increased incidence of cancer.

# OBJECTIVES

- To measure the effect of fall renovation treatments on $PM_{10}$ emissions during raking of debris following scalping of common bermudagrass fairways prior to overseeding.

- To measure the effect of fall renovation treatments on the percent green bermudagrass coverage before and after overseeding the fairways with perennial ryegrass.

# MATERIALS AND METHODS

## Study Site

- Mature, in-use common bermudagrass fairways located at The Springs Club, Rancho Mirage, CA.

## Treatments

- Dry: 21 days irrigation off, then scalp and rake same day
  - Sept. 15, irrigation off
  - Oct. 6, scalp and rake
- Dry-wet: 22 days irrigation off, then wet, scalp, and rake same day
  - Sept. 15, irrigation off
  - Oct. 7, scalp, irrigate 2 minutes (0.02 inch water; one turn of a fairway-type irrigation head) and immediately rake
- Primo: 7 days irrigation off, apply Primo, then 3 days later scalp and rake
  - Sept. 27, irrigation off
  - Oct. 4, apply Primo WSB (rate=0.75 ounces Primo Liquid/1000 $ft^2$)
  - Oct. 7, scalp and rake
- Reward: 1 day irrigation off, apply Reward, then 2 days later scalp and rake
  - Oct. 6, irrigation off
  - Oct. 7, apply Reward (rate=1.3 quarts/acre) plus Activator 90 (1 pint/acre)
  - Oct. 9, scalp and rake[z]

[z]Please note that on Oct. 9, 4:00 am, there was an unplanned irrigation for 5 minutes (0.06 inch).

## EXPERIMENTAL DESIGN

- Analysis of variance = completely randomized design; treatment mean comparisons = Fisher's protected least-significant-difference (LSD) test.

- Four plots (replications) of each treatment.

- Individual plot area ≈ 0.5 acre.

- Plots arranged over 14 fairways:

| Fairway | Treatment | Replication |
|---|---|---|
| 1 tee | dry | 1 |
| 1 green | Primo | 1 |
| 2 fairway | Reward | 1 |
| 3 fairway | dry | 2 |
| 4 fairway | dry | 3 |
| 6 fairway | dry | 4 |
| 7 fairway | dry-wet | 1 |
| 9 tee | Reward | 2 |
| 9 green | Reward | 3 |
| 10 fairway | Primo | 2 |
| 11 fairway | dry-wet | 2 |
| 13 fairway | dry-wet | 3 |
| 14 fairway | Primo | 3 |
| 16 fairway | Primo | 4 |
| 17 fairway | Reward | 4 |
| 18 fairway | dry-wet | 4 |

## SCALPING PROCEDURE

- Normal cutting height = 0.5 inch.
- Scalping via one pass flail mower, cutting height = 0.25 inch.
- Raking occurred 0.5 hour later.

## MEASUREMENTS – VISUAL TURFGRASS RATING

- Percent green bermudagrass coverage, 1 to 100% scale.

- Percent turfgrass coverage, 1 to 100% scale.

- Visual turfgrass quality of an overseeded bermudagrass fairway, 1 to 9 scale, 1 = brown, 5 = minimally acceptable, and 9 = best overseeded bermudagrass fairway.

## RAKING AND MEASUREMENTS – $PM_{10}$ EMISSIONS[z]

- A Toro Rake-o-Vac was used for raking and measuring $PM_{10}$ emissions. A hood was constructed over the top of the raker to direct the air rearward. The Toro is powered with a dedicated gasoline motor. The blower was operated at the maximum speed of 1580 rpm for all raking operations. Plots were raked at a ground speed of 6 miles/hour. The raking brush is 61 inches wide.

- The two $PM_{10}$ samplers mounted on the turf raker were cyclones specifically developed by the South Coast Air Quality Management District for sampling $PM_{10}$ directly from source exhausts. The cyclone-type samplers were needed to separate $PM_{10}$ from the larger debris.

- Filters were used to collect $PM_{10}$ emissions and were weighted before and after sampling to the nearest microgram.

- Volumetric output of the raker was determined. Average velocity was 2.7 m/second and this was used to calculate the flow rate = 200 cubic meters/minute based on the outlet exhaust area of 1.9 x 0.6 meters.

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[z] Fitz, D.R. 1995. Measurement of $PM_{10}$ emissions from a turf raker and evaluation of a water- spray control technology. Final Report. South Coast Air Quality Management District, Contract No. 95060.

Fitz, D.R. 1998. Evaluation of fugitive dust technology for a lawn raker. Final Report. Coachella Valley Association of Governments, Contract No. 0105.

Fitz, D.R. 1999. Dust control strategies for turf raking. Phase I Report. Coachella Valley Association of Governments.

Table 1. Calendar of major activities.

| Date | Activity |
|---|---|
| Sept. 1-14 | • Reduce irrigation; average daily irrigation = 49% $ET_o$ |
| Sept. 15 | • Irrigation off<br>• Stop mowing |
| Sept. 21-22 | • Rain<br>• A decision to conduct study |
| Sept. 23 | • Begin irrigation for Primo and Reward plots |
| Sept. 27 | • Irrigation off for Primo plots |
| Oct. 4 | • Close date for The Springs Club<br>• Apply Primo treatment<br>• Turfgrass visual ratings |
| Oct. 6 | • Scalp and rake dry plots; take $PM_{10}$ measurements<br>• Irrigation off for Reward plots |
| Oct. 7 | • Scalp and rake Primo and dry-wet plots; take $PM_{10}$ measurements<br>• Apply Reward treatment |
| Oct. 9 | • Scalp and rake Reward plots; take $PM_{10}$ measurements |
| Oct. 11 | • Visual turfgrass ratings<br>• Overseed fairways (also Oct. 12) |
| Oct. 19 | • Visual turfgrass ratings |
| Nov. 5 | • Open date for The Springs Club |
| Nov. 24 | • Visual turfgrass ratings |

## RESULTS AND DISCUSSION

### Treatment Effect on $PM_{10}$ Emissions

- The dry-wet treatment had significantly lower $PM_{10}$ emissions than the dry treatment (Table 2). These data show that the wetting (syringing) of debris resulting from scalping with a minimal amount of water (0.02 inch) followed by immediately raking is an effective best management practice (BMP) for reducing $PM_{10}$ emissions and dust. It should be noted that dry and dry-wet treatments were within the range of dry-down procedures practiced on Coachella Valley golf courses.

- The Primo treatment was not significantly different than the dry treatment for $PM_{10}$ emissions.

- The Reward treatment data were confounded by the unplanned 4:00 am irrigation (0.06 inch). It is difficult to discern how much of the low $PM_{10}$ emissions of this treatment were due to the minimal dry-down time (3-day interval between irrigation off and scalping and raking) or the syringing on the same day of scalping and raking.

### Treatment Effect on Percent Green Bermudagrass

- The dry and dry-wet treatments had the lowest percent green bermudagrass coverage among the treatments on Oct. 4 (2 days before initiation of scalping and raking activities) (Table 3). These data would be expected since the interval between irrigation off and scalping and raking was 21 days (dry) and 22 days (dry-wet).

- There was a nonsignificant trend for the dry and dry-wet treatments to have the lowest percent green bermudagrass through November 24. These data suggest that a dry-down period prior to overseeding was our most effective treatment (vs. a Primo or Reward treatment) for reducing bermudagrass competition during the fall transition from bermudagrass to overseed turfgrass.

## Future Research

- From a research perspective, the dry, dry-wet, and Primo treatments need to be repeated on several golf courses in Fall 2000. Not less than four replications per treatment should be tested at each golf course.

Table 2. The effect of four fall renovation treatments in 1999 on $PM_{10}$ emissions during raking of debris with a Toro Rake-o-Vac traveling at 6 miles per hour following scalping of common bermudagrass fairways prior to overseeding at The Springs Club, Rancho Mirage, CA.

| Treatment | $PM_{10}$ emission rate | | Interval between irrigation off and scalp/rake (day) |
|---|---|---|---|
| | g/mile | g/minute | |
| Dry | 99.0 a[z] | 9.9 a | 21 |
| Primo | 65.4 a | 6.5 a | 10 |
| Dry-wet | 1.2 b | 0.1 b | 22 |
| Reward[y] | 2.2 b | 0.2 b | 3[x] |
| LSD, $P$=0.05 | 50.7 | 5.1 | – |
| CV (%)[x] | 78.5 | 78.5 | – |

[z] Means followed by the same letter are not significantly different, Fisher's protected least-significant-difference (LSD) test. LSD is the least significant difference between two treatment means before they are significantly different at the $P$=0.05 level.

[y] Note: unplanned 5-minute irrigation (0.06 inch water) on the day of scalping and raking.

[x] CV is the coefficient of variation, a unitless calculation for the amount of variation in the population of measurements. Visual ratings, clipping yields, and root mass measurements normally have CVs in the range of 2 to 5, 15 to 25, and 40 to 60, respectively.

1998 study, Golf Resort at Indian Wells, one plot/treatment, raked with the same Toro Rake-o-Vac as in the 1999 study, $PM_{10}$ emission rate (g/mile): dry = 1.43; Primo = 0.62; dry-wet = 0.66.

Table 3. The effect of four fall renovation treatments in 1999 on the percent bermudagrass green coverage and turfgrass coverage during the fall and winter that is in conjunction with the overseeding of common bermudagrass fairways at The Springs Club, Rancho Mirage, CA.

| | Date[z] | | | | Date |
|---|---|---|---|---|---|
| | Percent bermudagrass green coverage | | | | Percent turfgrass coverage |
| Treatment | Oct. 4 | Oct. 11 | Oct. 19 | Nov. 24 | Oct. 11 |
| Dry | 17 c[y] | 2 b | 22 b | 57 bc | 81 c |
| Primo | 67 b | 5 a | 34 b | 72 ab | 96 ab |
| Dry-wet | 34 c | 3 ab | 30 b | 56 c | 86 bc |
| Reward | 97 a | 2 b | 50 a | 80 a | 99 a |
| LSD, *P*=0.05 | 21 | 2 | 14 | 15 | 10 |
| CV (%)[x] | 25.6 | 42.9 | 27.4 | 15.1 | 7.5 |

[z] Oct. 4 = Before any treatment plots were scalped and raked.

Oct. 11 = Day of seeding, 2 days after the completion of all treatment plots being scalped and raked.

Oct. 19 ≈ 7 days after seeding.

Nov. 24 ≈ 43 days after seeding.

[y] Means followed by the same letter are not significantly different, Fisher's protected least-significant-difference (LSD) test. LSD is the least significant difference between two treatment means before they are significantly different at the *P*=0.05 level.

[x] CV is the coefficient of variation, a unitless calculation for the amount of variation in the population of measurements. Visual ratings, clipping yields, and root mass measurements normally have CVs in the range of 2 to 5, 15 to 25, and 40 to 60, respectively.

# CONCLUSIONS

The dry treatment was the worst case for $PM_{10}$ emissions at 99 g/mile. Our dry treatment would be considered a rather dry condition by most golf course superintendents. The width of the reel or brush for a Rake-o-Vac is 61 inches.

This rate = 160.8 g $PM_{10}$/acre
= 3.54 lb $PM_{10}$/10 acre
= 12.39 lb $PM_{10}$/The Springs Club (though there are 125 acres of fairways and roughs that are scalped, only 35 acres of fairways are swept)

** Some caution should be exercised concerning the above information because it is based on only one season of data. **

It is true that the above $PM_{10}$ emission rates do not compare to an average day in the Coachella Valley where 49 ton $PM_{10}$ are produced.

However, the Hi-Lo Desert GCSA has the opportunity to continue to provide leadership in being good stewards of the environment and practice the best management practices (BMP) of syringing debris before raking and significantly reducing $PM_{10}$ emissions. The operators of the rakers may also appreciate the reduction of dust.

Also, by practicing this BMP and educating the Coachella Valley green industry to practice this BMP, the Hi-Lo Desert GCSA can help make the case for redesignation of attainment for $PM_{10}$, which will benefit all of the Coachella Valley.