Algae Control in Bentgrass (*Agrostis palustris*) with DC5772® and Profile™

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(ABSTRACT)

Despite efforts at both cultural and chemical control, the growth of surface algae in fine turf has become a problem for golf course managers nationwide. Most turfgrass management problems with algae occur during the summer when excess irrigation and warm temperatures are combined with high light intensities (2).When the population level is high, algae form a mat of dark green to black slime layer on the soil surface. This mat will cause problems with aesthetics, playability, and cultural conditions. Chemicals presently labeled to manage algae in turf do not meet acceptable control levels. Alkoxysilanes are used for the control of algal growth in water intended for domestic and industrial uses (3). This compound has also been found to exhibit algicidal activity while chemically bonded to a variety of substrates (1,3). This investigation was designed to test the hydrolysis product of an alkoxysilane compound, 3-(trimethoxysily)-propyldimethyloctadecyl ammonium chloride (Si-QAC), chemically bonded to a porous ceramic soil modifier, Profile™, to control algae in fine turf. Both field trials and laboratory experiments were conducted. The field experiments were set up at two locations and were rated visually. Four rates of Si-QAC (0.0%, 0.01%, 0.1%, 1.0% a.i.) dried to Profile™ were compared against two fungicides, Daconil Weather-Stik™ and Fore™, and two rates of Algaen-X™. Mist chamber experiments were also conducted in which experimentally treated Profile™, was inoculated with a suspension of algal cells. A chlorophyll analysis was performed as a means of quantifying the algae present in each treatment. Field research demonstrated the Profile™ treatments out performed the liquid fungicide treatments in controlling surface algae. However, there was little statistical separation between the Profile™ treatments indicating Profile™ alone may posses some degree of algae control. Mist chamber studies showed that amended Profile™ was able to delay the colonization of algae. It was also noted the 1.0% a.i. caused the Profile™ to become hydrophobic. Management practices which promote a dry soil surface coupled with a preventative fungicide/algicide program are the only means available to combat surface algae as long as environmental conditions favor their development.

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INTRODUCTION

Despite efforts at both cultural and chemical control, the growth of surface algae in fine turf has become a major problem for most golf course managers nationwide. Not only does the growth of algae affect the quality of golf course greens by disrupting an otherwise smooth putting surface, its presence also produces harmful affects to the plants, thus compromising the health of the turf.

In large numbers, algae form a mat of dark green to a black slime layer on the soil surface. If allowed to dry, the slime layer will develop into a hard crust. Whether hydrated or not, this layer functions as a physical barrier by clogging the pores of the soil surface. This decreases the infiltration rate of the underlying soil preventing water, gas (O_2, CO_2), and chemicals such as fertilizer and pesticides from moving freely throughout the soil profile. Algae also compete for space and the resulting barrier obstructs the surrounding turf from creeping and/or reestablishing itself in algae infested areas. Secretion of allelopathic chemicals has been shown to occur in aquatic algae (9, 10). It can only be speculated to occur in a terrestrial environment where certain algal species may excrete toxins which prevent growth and/or germination of turfgrass (7).

Chemicals presently labeled to manage algae in turf do not meet acceptable control levels set by the golfing public and modern day golf course managers. Clearly there is a need for an effective algae control in the area of turfgrass management.

Alkoxysilanes are used for the control of algal growth in water intended for domestic and industrial uses (12). This compound has also been found to exhibit algicidal activity while chemically bonded to a variety of substrates, including ceramic (8,12). This investigation was designed to test the hydrolysis product of an alkoxysilane compound, 3-(trimethoxysilyl)-

propyldimethyloctadecyl ammonium chloride (Si-QAC), chemically bonded to a porous ceramic soil modifier, Profile™, to control algae in golf course managed turfgrass.

Both field trials and laboratory-based mist chamber experiments were conducted. The field experiments were set up at two separate locations, each duplicated. Four different rates of Si-QAC (0.0%, 0.01%, 0.1%, 1.0%) dried to Profile™ were compared against two fungicides, Daconil Weather-Stik™ and Fore™, and two rates of Algaen-X™. In total, each plot site held nine treatments randomly blocked four times in 0.61 meter by 0.61 meter plots.

Laboratory based mist chamber experiments were conducted in which trays containing experimentally treated Profile™ were inoculated with a suspension of algal cells. The primary inoculin was allowed to incubate under continuous misting conditions. A chlorophyll analysis was then performed as means of quantifying the amount of algae present in each treatment.

LITERATURE REVIEW

Algae are typically defined as thallophytes (plants lacking roots, stems, and leaves) that have chlorophyll *a* as their primary photosynthetic pigment and lack a sterile covering of cells around the reproductive cells (10). This definition encompasses a number of plant forms that are not necessarily closely related. For example, the Cyanophyta (blue-green algae) and Prochlorophytes have features closer to bacteria (procaryotes) than to the rest of the algae (eucaryotes) (10).

Occurrence and Habitat

In general, most turfgrass management problems with algae occur during the summer when excess irrigation and warm temperatures are combined with high light intensities (13). Problems with algae are most likely to occur in locations that retain surface water for an extended period of time. This includes areas of poor air movement, shading, and slow surface drainage due to compaction or excess thatch (7). To counteract summer conditions of excessive heat and transpiration, golf course managers irrigate frequently to prevent wilting. Colonization of surface algae is also favored by intense levels of sunlight. Due to demands from golfers for a faster putting surface, golf greens are being cut at lower mowing heights. Some golf courses are cutting their greens as low as 0.25 centimeters. This allows more light to penetrate the canopy, subsequently promoting algal growth (1,2). Furthermore, bentgrass is not adapted to tolerate such ultra low mowing heights. The turf becomes weakened under such conditions, causing it to thin, thereby compounding the problem by allowing additional light to penetrate the canopy.

Species

Species within the division Cyanophyta (blue-green algae) and Chlorophyta (green algae) are recognized as being responsible for the formation of mats of algae on golf course greens (Table 1) (1,2,7). *Phormidium* has been the dominant genus in samples of algae taken from golf courses in southwest Virginia. Because both turfgrass and algae require similar growth factors (water, nutrients, and light), aquatic and terrestrial algal species are able to persist on golf greens (1,2). Irrigation water, however, does not appear responsible for spreading the aquatic populations to greens (3,4).

Table 1. Genera of algae commonly found on golf course greens.

Chlorophyta	*Cyanophyta*
Chlamydomonas	*Lyngbya*
Chlorococcum	*Nostoc*
Cylindrocystis	*Phormidium*
Hormidium	*Schizothrix*
Cosmarium	*Oscillatoria*
Mesotainium	*Fremyella*
Chlorella	*Sympbea*

Factors such as geographic location, season and soil pH can influence the species composition of a golf course green. Species are found to be geographically dependant and may shift in predominance with changes of season (1,8). Various groups of algae populations also have different pH preferences. The green algae prefer acidic soils whereas blue-green algae prefer alkaline conditions (1). Golf greens are managed in a pH range (7.0-6.0) which is favorable to the growth and development of blue-green species (1,19). This partially explains the dominance of blue-greens over green algae found on golf greens.

Control

One of the main recommendations for controlling algal mats is to alter the site to improve drainage or facilitate surface drying (1,9). A study performed in 1995 by Colbaugh and Metz (14) demonstrated algal control was greater in treatments where the surface was allowed to dry between irrigations compared to a shady area with frequent irrigations. Drainage can be improved by aerification and top dressing (or backfilling) with a porous material. Overall drainage can also be enhanced by unblocking drainage pipes and employing proper irrigation practices (9). Proper irrigation practices include avoiding saturated conditions by hand watering elevated/dry regions of the green. Increasing air movement around a green, by pruning shrubs and trees, will assist in keeping the site dry. Selective pruning will also minimize the amount of shade covering the green.

Cyanophyta are generally more difficult to control with chemical treatments than are the Chlorophyta (13). In addition to the Cyanophyta being better adapted to the pH range where golf greens are managed, they also posses a mucilage layer (sheath or capsule) outside the cell wall (10). This sheath functions in protecting the cell from drying and may also protect it from direct emical contact.

Copper sulfate, hydrated lime, sodium hypochlorite, fungicides, and herbicides have been n attempt to control algae (1,2,3,4,5,9). Commercial corn gluten enzymatic hydrolysate, Digester +® a commercially available enzymatic product, and cottonseed enzymatic hydrolysate were found to be effective in controlling *Phormidium* sp. algae in laboratory investigations (13). The problem with using certain chemicals (copper sulfate, sodium hypochlorite) is they are also toxic to the turf (5). Hydrated lime can be used as a desiccant (5). Although using hydrated lime may be effective to suppress the green algae, it may stimulate growth of blue-green algae which are favored by a higher pH (11). Altering soil chemistry can also have detrimental effects on nutrient availability, chemical applications, and turf growth.

Although the fungicides mancozeb and chlorothalonil are labeled for the control of algae on turf, they have not proven to provide acceptable control during field studies (7,14). The use of demethylation inhibitor (DMI) fungicides has been found to effect the growth of algae. Burpee and Stephens (16) demonstrated the colonization of algae (species not reported) were highest in field plots treated with the DMI fungicides (propiconozole, triadimefon, myclobutanil, cyproconazole) compared with an untreated check and chlorothalonil. The DMI treatment plots were also heavily colonized with Rhizoctonia blight (*Rhizoctonia solani*). However, the untreated check also showed severe disease incidence and statistically significant lower percent surface algae than the DMI treated plots. Indicating the applied DMI fungicides may have created an opportunity for the invading algae by thinning the turf.

Orcutt tested on the effects of four DMI fungicides (fenarimol, myclobtanil, propiconazole, triadimefon) on growth and sterol synthesis of seventeen species of algae representing five classes (Chlorophyceae, Cyanophyceae, Bacillariophyceae, Euglenophyceae, Rhodophyceae) (15). He found that sensitivity was species, chemical, and concentration dependant. On average, the DMIs inhibited growth in a large number of algae species. Propiconazole was the most effective DMI with respect to growth inhibition while triadimefon was the least effective (15). The most sensitive species were *Chlorella pyrenoidosa* and *Oocystis polymorpha* (both green algae) (15). However, *Chlorella salina* and *C. ellipsoidea* were stimulated at 5ppm by some of the DMIs (15). Other tolerant species were *C. vulgaris*, *C. infusionum* var *actophila* and *Euglena gracilis* which required 10 or 20 ppm of the DMI's to inhibit growth (15).

The most successful chemical used to control algae has been a quaternary ammonium chloride (QAC), Algaen-X™ (1,3,4,5). Colbaugh (4,5) has demonstrated experimentally that Algaen-X can be used to manage algal populations on turf; however, there are at least three problems with this method of algae control. First, there have been some situations where Algaen-X has been phytotoxic to turf. Second, Algaen-X is labeled as a drench treatment, up to 37.85 liters of water per 92.9 square meters. Applying this amount of water to an area is very time consuming and expensive. Third, Algaen-X is readily leached from the area of application.

An investigation by Isquith et al. (8) in 1973 compared the effectiveness of an organosilicon quaternary ammonium chloride (Si-QAC) and QAC (Algaen-X) on *Streptococcus faecalis*. On surfaces exposed to QAC, 750 out of 1,000 organisms survived compared to two survivors on the Si-QAC exposed surfaces. Furthermore, one 4-minute wash permitted 100 percent survival of *S. faecalis* on the QAC treated surface. This suggests QAC may be removed from the site of application after irrigation. In contrast, after 50 washes (200 minutes), glass treated SI-QAC yielded a 5 percent survival rate of *S. faecalis*. QAC and Si-QAC disrupt the integrity of the cell wall and cell membrane, although *S. faecalis* is a bacterium, the cell wall and membrane structure is similar to cyanophyta.

FIELD RESEARCH

Materials and Methods

This study was conducted during the summer of 1996 on two golf courses in south west Virginia. At research site 1, treatment plots were located on bentgrass (*Agrostis palustris*) managed tees at West Lake Country Club, a golf course in the Smith Mountain Lake area. Two separate trials were performed, one on the 14th tee and one on the 18th tee. The area selected on the 14th tee received shade, had excellent ground cover, and was heavily infested with algae. The area selected on the 18th tee received full sun, had poor ground cover, and was moderately infested with algae. Research site 2 was located on bentgrass/annual bluegrass (*Poa annua*) managed greens at the Virginia Tech Golf Course in Blacksburg. Two separate trials were conducted. The first trial was located on the 12th green which collects water from the front and the left side of the putting surface. One week prior to the first application, the entire green was covered by water after a heavy rain storm. Ground cover was moderate, and the incidence of algal colonization was high. The second trial was located on the 13th green. This site is elevated and sloped from back to front. The ground cover was thin, and the incidence of algal colonization was moderate.

Treatments for these trials included application of spray and granular applied chemicals. Mancozeb, chlorothalonil, and a quaternary ammonium product (Algaen-X™) were used in the liquid treatments. The experimental combination of DC5772 and Profile™ was applied as a granule. Granular treatments were applied using a Scotts® two foot drop spreader calibrated to put down 0.08 cm^3 of Profile™ per pass while walking three miles per hour. Liquid treatments were applied using a CO_2 back-pack sprayer equipped with an 8002 Tee-jet nozzle calibrated to distribute a flat fan pattern at 40 psi. Fungicides used in this study were applied as the amount of formulated product (f.p.) per 92.9 m^2 in 26.5 liters of water per 92.9 m^2. Chlorothalonil (Daconil Weather Stik™) was applied at 177.4 ml. Mancozeb (Fore™) was applied at 283.9 ml. These rates are the manufacturers' recommended rates for the control of algae. QAC (Algaen-X™) was applied at two rates. The first rate was applied according to the label (1.0 pint f.p. in 321.8 liters of water to treat 929.0 m^2), and the second was an experimental rate of Algaen-X™ first used by Colbaugh (2.2 ml f.p. in 220.0 ml of water to treat 0.372 m^2). For a complete listing of rates of chemical application see Table 2.

Samples of algal mats were collected from treatment plots before the first chemical application. Samples were then characterized by examination with the aid of a microscope and keyed to genera. *Phormidium*, *Chlorella*, and *Cylindrocystis* were found to be the dominant genera.

Source of chemicals. Si-QAC (DC5772) was obtained from the Dow Corning Corporation and formulated at 72.1 percent active ingredient. Daconil Weather Stick™, Fore™, and Algaen-X™ were obtained from their respective manufacturers, see Table 3.

Preparation of treated surface. Four experimental rates of DC5772 (1.0%, 0.1%, 0.01%, 0.0%), calculated by active ingredient, were used to treat the inert carrier-Profile™. Profile™ and DC5772 were mixed in a 5 gallon rotating cement mixer until the contents of the container were uniformly saturated. The wet material was then spread onto benches to dry.

Algae control was determined by visual inspection of viable algae present in each plot. Viability was determined by color: green/black algal mats were determined to be living and grey algal mats were determined to be non-viable. A visual index number was assigned to each treatment plot (0-5, 0=total control; 5=no control). All treatment plots were 0.19 m^2 and arranged in a randomized complete block design. The treatments were replicated four times except on the 18th tee, at site 1, where it was replicated three times. The data was subject to protected analysis of variance and compared by means of Duncan's multiple range test (21).

LABORATORY RESEARCH

Materials and Methods

Source of chemicals. Si-QAC was obtained from the Dow Corning Corporation formulated at 72.1 percent 3-(trimethoxysilyl) propyldimethyloctadecyl ammonium chloride (Table 3).

Culture Medium. Stock cultures were maintained in petri plates on Bristol's solution and soil extract agar medium (17). Liquid cultures were maintained in 2,000 ml Erlenmeyer flasks containing a combination of distilled water and water soluble fertilizer (Lebanon® Spray Gro® 20-20-20, NPK) (Table 3).

Source and Maintenance of Cultures. The algal culture used in this experiment was *Phormidium faveolarum*, received from the University of Texas (UTEX # B427). *Phormidium* is a cyanobacterium commonly found on golf course putting greens in southwest Virginia. Cultures were first grown in petri plates on Bristol's and soil extract agar medium (17) to increase inoculum levels. The plates were covered with a layer of cheese cloth, grown under fluorescent lamps, and incubated at 27°C ±2°C. Sections of agar (with cells) were harvested from the petri plates and transferred to 1,000 ml of deionized water and nutrient solution (20-20-20 NPK). The liquid suspension was then incubated under fluorescent lamps at 27°C±2°C and shaken daily.

Preparation of treated surface. Four experimental rates of DC5772 (1.0%, 0.1%, 0.01%, 0.0%), calculated by active ingredient, were used to treat the inert carrier-Profile™. Profile™ and DC5772 were mixed in a 5 gallon rotating cement mixer until the contents of the container were uniformly saturated and then spread onto benches to dry.

The effects of four rates (0.0%, 0.01%,0.1%,1.0%) of DC5772 bonded to Profile™ were compared for their ability to control algae growth. Treatments were conducted as a randomized complete block design, replicated four times and placed inside a mist chamber. One hundred cm^3 of an experimental rate of treated Profile™ was placed in 15cm X 11cm X 6 cm plastic trays. Trays were perforated at the bottom and lined with Kimwipes®. The containers inoculated with a liquid suspension of cells. Inoculum applications were performed with a CO_2 backpack sprayer dispensing liquid at 30 psi from a flood-jet nozzle. Containers were then randomly placed in a mist chamber.

The mist chamber was maintained at 27°C, with circulated water vapor 24 hours per day. Low levels of light were used at first, and gradually increased with time in order to prevent bleaching the thin layer of primary inoculum. Incandescent (60 watt, 130 volt) and fluorescent (cool white, high output, 60 watt flud bulb) lamps were used. Initially, one incandescent and two fluorescent lamps were used. The incandescent bulb was increased by one and the fluorescent lamps were increased by two every two days until a total of five incandescent and ten fluorescent lamps were operating on a 16hr/8hr day/night interval.

Chlorophyll levels used as criterion for measuring algal growth. Three ratings were made on seven day intervals for each plot. For every rating, 15 cores were extracted from each treatment plot using a 9 millimeter (mm) cork borer. Cores were placed in screw cap tubes (100 mm X 13 mm) and 2 milliliters of 80 percent acetone was added. Trays were then returned to the mist chamber. Each tube was vortexed for 15 seconds and centrifuged at 2000 rpm for 60 seconds. The supernatant was recovered and analyzed for chlorophyll content with a spectrophotometer (Bausch and Lomb Spectronic 20) at 663 nanometers (20).

RESULTS AND DISCUSSION

The field research demonstrated that all amended and non-amended Profile™ treatments were more effective than the liquid treatments in controlling surface algae (Figures 1,2,3,4; Tables 4,5,6,7). Profile™ treated with 1.0 percent DC5772 (Si-QAC) consistently gave the best results at both locations of West Lake Country Club (Figures 1,2; Tables 4,5) and at both locations on the Virginia Tech Golf Course (Figures 3,4; Tables 6,7). However, except for a few ratings, Profile™ treated with 0.0 percent DC5772 displayed a degree of algae control not statistically different than the Profile™ treated with 1.0 percent DC5772. This suggests that Profile™ alone possesses a partial degree of control on surface algae. Profile™ has the ability to absorb relatively large quantities of water. The manufacturer recommends this product be watered immediately after application to prevent wilting of the plant (22). This feature may limit the amount of free water present thereby suppressing the growth of surface algae.

The algae population levels in the plots treated with the liquids were not statistically significant from the plots not treated (Tables 4,5,6,7). It was also observed that all rates tested, both liquid and granular, were not phytotoxic to the turf.

This research supports previous findings with respect to mancozeb and chlorothalonil as algicides. These materials are foliar contact fungicides and are usually applied in two to three gallons of water per 1000 ft^2 for adequate coverage of the leaf blade. During this experiment, however, applications were made in six gallons of water per 1000 ft^2 in order to deliver the active ingredient to the soil surface. The degree of control provided by these materials was not acceptable where the management of high quality fine turf is concerned.

Neither of the Algaen-X™ treatments were able to provide an acceptable level of control of surface algae. Although quarternary ammonium is highly toxic to algae, in liquid form this material is readily leached from the area of application. This problem is exacerbated on greens and tees that are irrigated at least once a day during summer months to prevent wilt. Therefore, although Algaen-X may show slight initial control, the algae are able to re-colonize once the chemical is washed away.

The experimental treatments of DC5772 bonded to Profile™ were able to suppress the growth of algae through direct chemical contact and by wicking away surface water. These properties however diminish significantly with time. This is due to the fact that direct cell to chemical contact must be made if complete control is to be achieved. However, with time, algae cells (or any other microorganism) on the treated surface die and thus chemical contact is blocked. This surface then becomes available for another algal cell to occupy it without coming in direct contact with the algicide. Consequently, after the algae are able to form this initial growth, the chemically treated Profile™ becomes ineffective. Surface penetration of water is also impeded once an initial layer of algae is formed. Soil pores become clogged, water is retained on the surface, thereby offsetting the initial impact of Profile™.

Laboratory results were similar to those of the field research. Once an initial layer of algae was able to establish itself, algae was free to colonize. This is especially the case with the Profile™ treated with 0.0 and 0.01 percent DC5772 during the 21 day ratings (Figure 5). The Profile treated with 1.0 percent DC5772 resulted in the least amount of algae from growing throughout the laboratory experiment (Figure 5). The optical density of Profile™ treated with 1.0 percent DC5772 never exceeded any of the other treatment ratings (Figure 5). However, the application of the Profile™ treated with 1.0 percent DC5772 caused the Profile™ particles to become hydrophobic. This effect further delayed algae from colonizing the surface of these treatments and could explain the low optical density. Even though Profile™ treated with 1.0 percent treatment was most effective in reducing the development of algae during laboratory and field experiments, the hydrophobic effect this rate brings about makes it unfit to apply as a growing medium. Most likely, after years of applying this rate of DC5772 bonded to Profile™ as a topdressing, retaining water in the root zone would be difficult.

DC5772 is formulated with methanol which is toxic to turfgrass; therefore, it would not be feasable to use this material as a spray treatment. Therefore, by drying this chemical to Profile™ the methanol is evaporated away making it safe for application. This union also ensures the algicide will be delivered where it needs to be for maximum effectiveness.

These findings illustrate that presently there are no effective means of satisfactory algae control. The most appropriate control program is one designed to slow the onset of rapid algae colonization by keeping the surface of the soil dry. In this respect, thatch management is very important. Even in coarse soil, a thatch layer will absorb and hold water like a sponge giving algae what it needs for survival. This is further reinforcement of the need for golf course managers to stay on an aggressive thatch management program. A minimum of two to three core aerifications per year coupled with light (1/16") frequent applications of topdressing will keep surface water to a minimum and help reduce thatch. Care should also be taken in watering practices to avoid free standing water.

Although it has been suggested that increasing the mowing height of golf greens may reduce algae populations, algae have been observed during the course of this research growing in tees cut at one quarter of an inch, making this recommendation a questionable one.

Management practices which promote surface drying coupled with a preventative fungicide/algicide program are the only means available to combat surface algae as long as environmental conditions favor their development.

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Table 2. Treatments and rates of field studies.

Trt. No.	Treatment Name	Rate	Plot Number by Rep. 1	2	3	4
1	CONTROL		101	207	302	406
2	DAC. W.S.	6*	102	204	306	405
3	FORE	9.6*	103	206	303	403
4	ALGAENX LABLE	1.6▫	104	209	304	402
5	ALGAENX COBAL	5.3▫	105	201	309	408
6	PROFILE 0.0	0.0 %‡	106	208	308	407
7	PROFILE 0.01	0.01%‡	107	205	305	404
8	PROFILE 0.1	0.1 %‡	108	202	307	401
9	PROFILE 1.0	1.0 %‡	109	203	301	409

* ounces of product per 1000 ft^2.
▫ ounces of product per liters of water per 1000 ft^2.
‡ percent active ingredient DC5772 dried to carrier.

Table 3. List of materials tested (18).

Trade Name	Common Name	Chemical Name	Manufacturer
Fore	Mancozeb	62% ethylene bisdithiocarbamate 10% manganese 2% zinc	Rohm and Haas Co. Independence Mall West Philadelphia, Pennsylvania 19105
Daconil Weather Stik	Chlorothalonil	Tetrachloroisophthalonitrile	ISK Biotech Corporporation 5966 Heisley Road P.O. Box 8000 Mentor, Ohio 44061
Algaen-X	Quaternary Ammonium Chloride	N-alkyl dimethyl benzyl ammonium chloride (QAC)	Grace Sierria 1001 Yosemite Drive Milpitas, California 95035
Dow Corning® 5772 Anti-microbial Agent	Organosilicon Quaternary Ammonium Chloride	3-(trimethoxysilyl) propyldimethyloctadecyl ammonium chloride (Si-QAC)	Dow Corning Corporation South Saginaw Road Midland, Michigan 48686
Lebanon ® Spray Gro® 20-20-20	Water soluble plant food (Fertilizer)	20% Total Nitrogen (N) 20% Available Phosphoric Acid (P_2O_5) 20% Soluble Potash (K_2O)	Lebanon Chemical Corporation 1600 E Cumberland Street, Lebanon, PA 1

Table 5. West Lake 18 tee ratings. Visual index number assigned to each plot: 0=total control, 5=no control.

		Rating Dates						
Trt. No.	Treatment Name	7-12-96	7-17-96	7-26-96	8-8-96	8-16-96	9-13-96	9-20-96
1	Control	4.7 a	4.0 a	4.0 a	3.3 ab	3.0 a	4.3 ab	4.0 a
2	Daconil W.S.	4.3 ab	3.0 ab	3.0 bc	3.0 abc	2.7 a	4.0 b	4.0 a
3	Fore Fl	4.3 ab	3.3 a	3.3 ab	3.5 a	3.0 a	4.0 b	3.7 a
4	AlgaenX Lable	3.7 bc	3.7 a	3.5 ab	4.0 a	3.0 a	5.0 a	4.3 a
5	AlgaenX Colbal	4.0 abc	3.7 a	3.0 bc	3.0 abc	2.7 a	4.0 b	4.0 a
6	Profile 0.0	3.3 cd	2.0 bc	2.3 cd	2.0 cd	1.0 b	2.0 cd	1.7 b
7	Profile 0.01	3.3 cd	1.7 c	2.7 bcd	2.3 bcd	0.3 b	2.3 c	2.7 b
8	Profile 0.1	2.7 d	1.7 c	2.3 cd	1.7 d	0.7 b	1.3 de	2.7 b
9	Profile 1.0	2.5 d	1.3 c	2.0 d	1.5 d	0.3 b	0.5 e	1.7 b
LSD (0.5) =		0.8	1.0	0.8	1.0	1.5	0.9	1.5
Standard Deviation =		.48177	.59706	.44839	.58714	.85139	.54189	.89494
CV =		13.21	22.08	15.42	21.72	45.89	17.73	28.10

Means followed by the same letter do not significantly differ (Duncan's MRT, P=.05)

Table 4. West Lake 12 tee rating. Visual index number assigned to each treatment: 0=total control, 5=no control.

Trt. No.	Treatment Name	Rating Dates 6-19-96	6-27-96	7-3-96	7-12-96	7-17-96	8-8-96	8-16-96	9-13-96	9-20-96	9-27-96
1	Control	3.8 a	3.3 a	4.3 a	4.3 a	5.0 a	4.0 a	4.2 a	4.0 a	3.5 ab	3.3 ab
2	Daconil W.S.	3.8 a	2.8 ab	3.5 b	3.8 b	4.5 a	3.5 a	3.3 a	3.8 a	2.8 b	2.8 bc
3	Fore Fl	4.0 a	2.8 ab	3.5 b	4.0 a	4.8 a	4.3 a	3.5 ab	3.8 a	2.8 b	2.5 bcd
4	AlgaenX Lable	4.3 a	3.3 a	3.0 b	4.3 a	4.5 a	4.5 a	3.8 ab	3.8 a	3.5 ab	3.8 ab
5	AlgaenX Colbal	3.8 a	3.0 ab	3.3 b	3.8 ab	4.8 a	4.3 a	3.9 ab	4.3 a	4.0 a	4.3 a
6	Profile 0.0	2.3 bc	2.3 bc	2.0 c	3.0 bc	2.8 b	1.6 b	0.3 c	1.8 b	1.3 c	1.8 cde
7	Profile 0.01	1.5 c	1.0 d	1.8 c	1.7 d	1.5 cd	1.5 b	0.3 c	0.5 c	0.8 c	0.8 e
8	Profile 0.1	2.5 b	1.7 cd	1.8 c	2.3 cd	2.0 c	1.5 b	0.5 c	0.7 bc	0.5 c	1.3 de
9	Profile 1.0	1.6 c	1.3 d	1.5 c	1.8 d	1.3 d	0.7 b	0.3 c	0.3 c	0.3 c	0.5 e
LSD (0.5) =		0.8	0.7	0.7	0.8	0.6	1.0	0.8	1.0	1.1	1.2
Standard Deviation =		.53721	.48409	.49535	.53763	.43033	.64459	.51165	.70169	.7698	.82916
CV =		17.71	20.45	18.20	16.88	12.49	22.34	23.12	27.75	35.99	35.96

Means followed by the same letter do not significantly differ (Duncan's MRT, P=.05)

Table 6. Virginia Tech 12 green ratings. Visual index number assigned to each plot: 0=total control, 5=no control.

Trt. No.	Treatment Name	Rating Dates 9-7-96	9-18-96
1	Control	4.4 a	3.5 ab
2	Daconil W.S.	4.3 a	3.3 ab
3	Fore Fl	3.7 ab	3.3 ab
4	AlgaenX Lable	3.3 b	4.0 a
5	AlgaenX Colbal	3.8 ab	3.5 ab
6	Profile 0.0	0.5 c	2.8 bc
7	Profile 0.01	0.3 c	2.6 bc
8	Profile 0.1	0.5 c	2.3 c
9	Profile 1.0	0.8 c	2.0 c
LSD (0.5) =		0.8	0.9
Standard Deviation =		.55304	.58583
CV =		23.36	19.43

Means followed by the same letter do not significantly differ (Duncan's MRT, P=.05)

Table 7. Virginia Tech 13 green ratings. Visual index number assigned to each plot: 0=total control, 5=no control.

Trt. No.	Treatment Name	Rating Dates 9-7-96	9-18-96
1	Control	3.3 ab	4.7 a
2	Daconil W.S.	3.8 a	3.8 a
3	Fore Fl	3.8 a	3.8 a
4	AlgaenX Lable	3.3 ab	3.8 b
5	AlgaenX Colbal	2.7 b	4.0 ab
6	Profile 0.0	0.5 c	2.8 c
7	Profile 0.01	0.1 c	2.8 c
8	Profile 0.1	0.8 c	2.5 c
9	Profile 1.0	0.3 c	1.5 d
LSD (0.5) =		0.7	0.8
Standard Deviation =		.50828	.54035
CV =		24.94	16.49

Means followed by the same letter do not significantly differ (Duncan's MRT, P=.05)

FIELD RESULTS

West Lake Country Club, 12th Tee

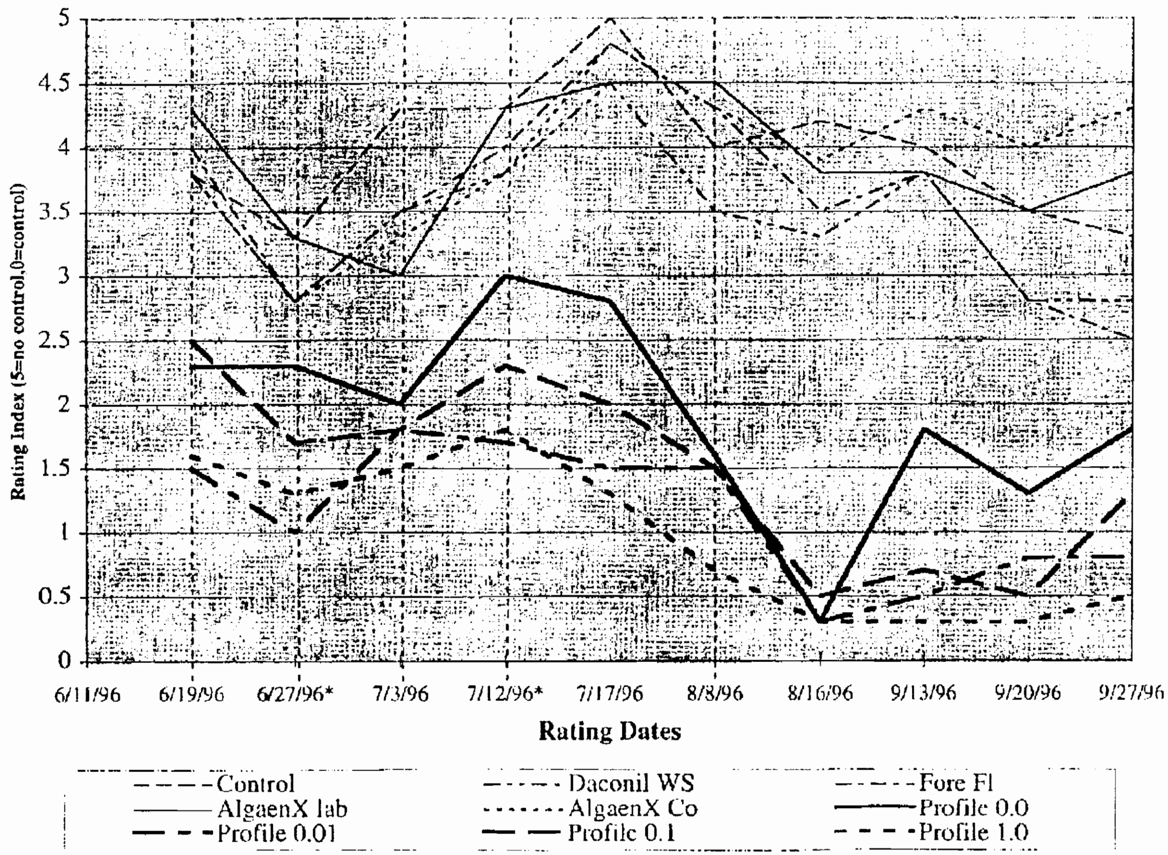

Figure 1. Field results from the 12th tee at West Lake Country Club. Broken verticle lines represent application dates.

* Application of liquid treatments only: Daconil, Fore, AlgaenX lable, AlgaenX cobal

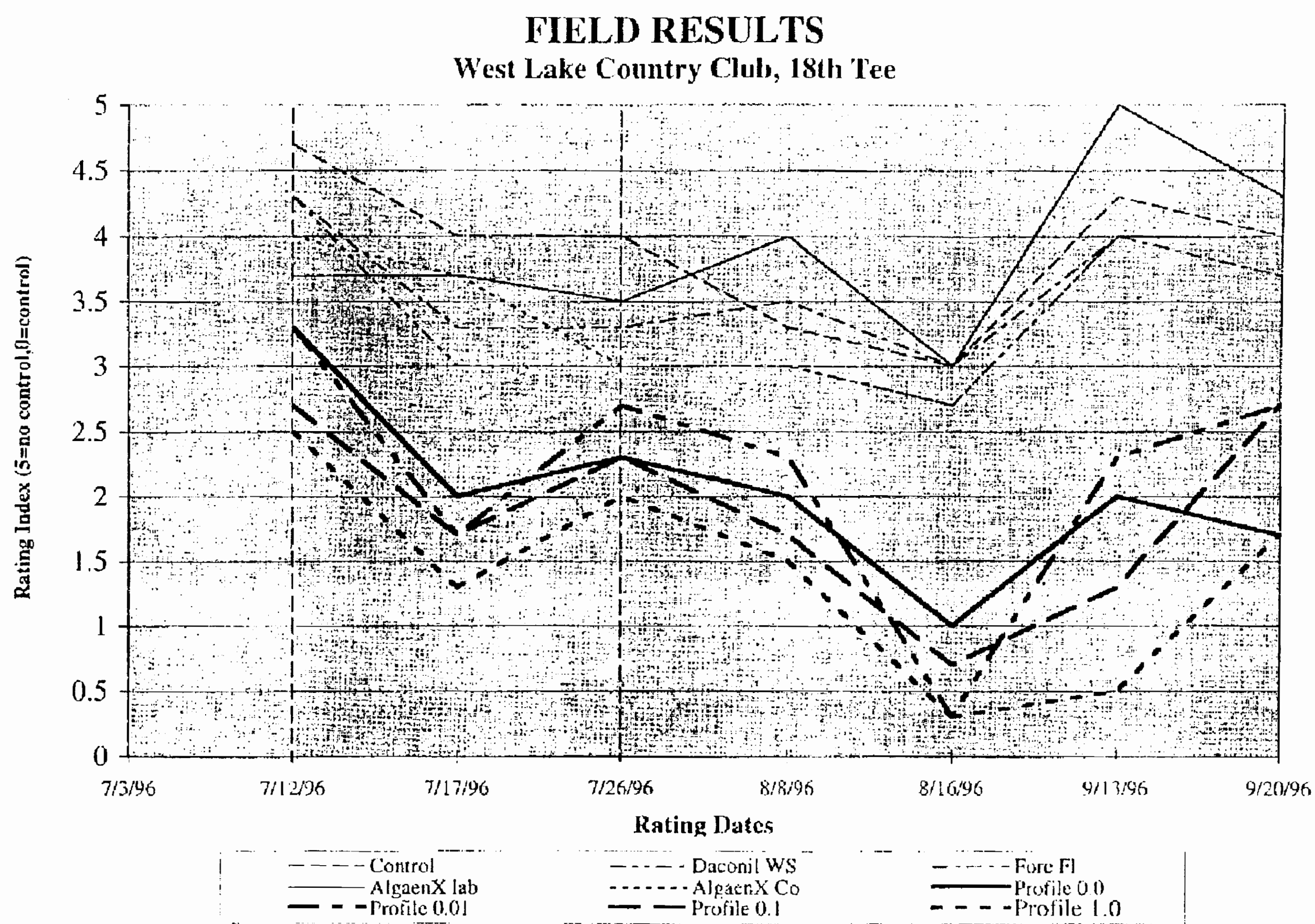

Figure 2. Field results from the 18th tee at West Lake Country Club. Broken vertical lines represent application dates

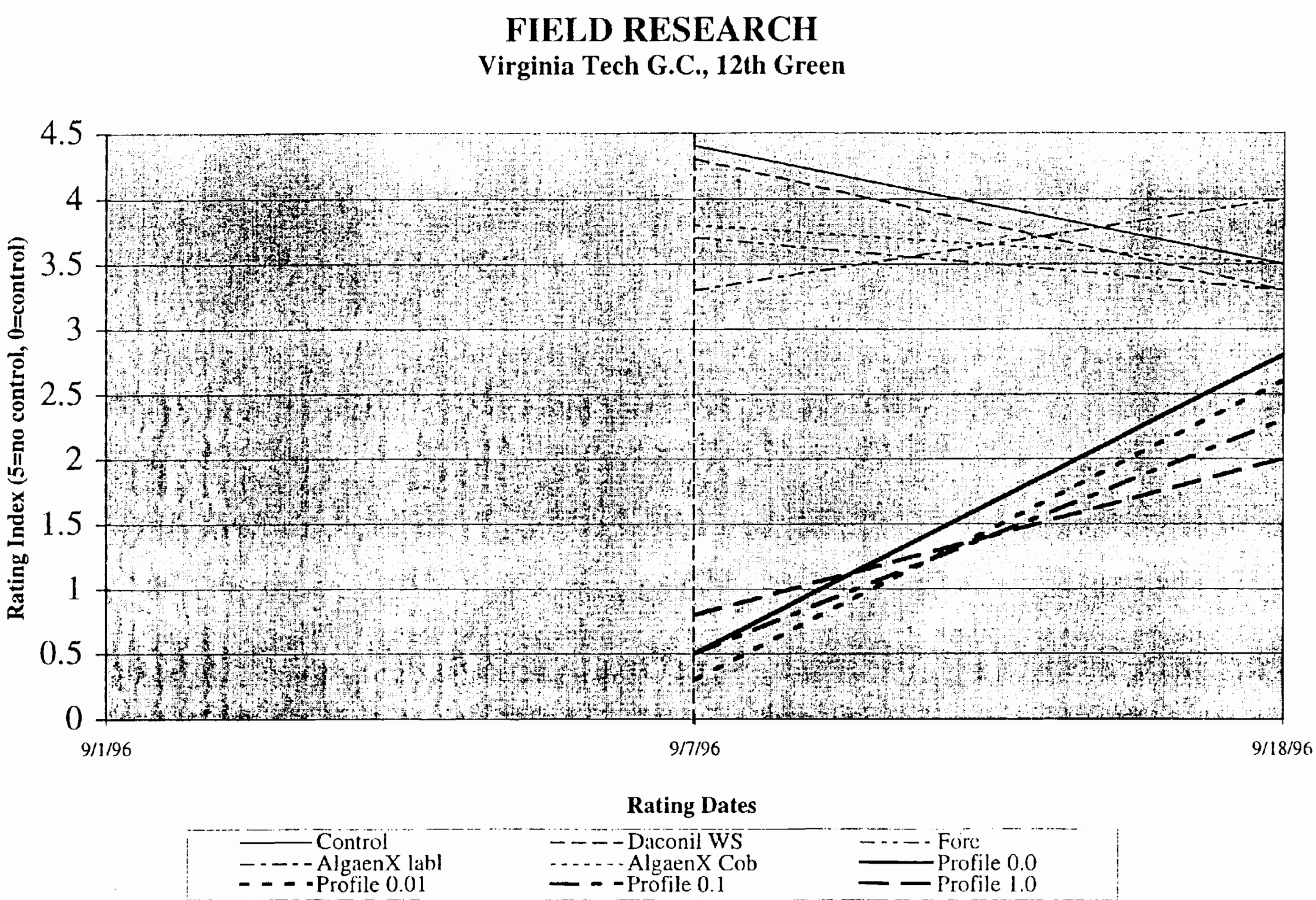

Figure 3. Field results from the 12th green at the Virginia Tech Golf Course. Broken vertical lines represent application dates.

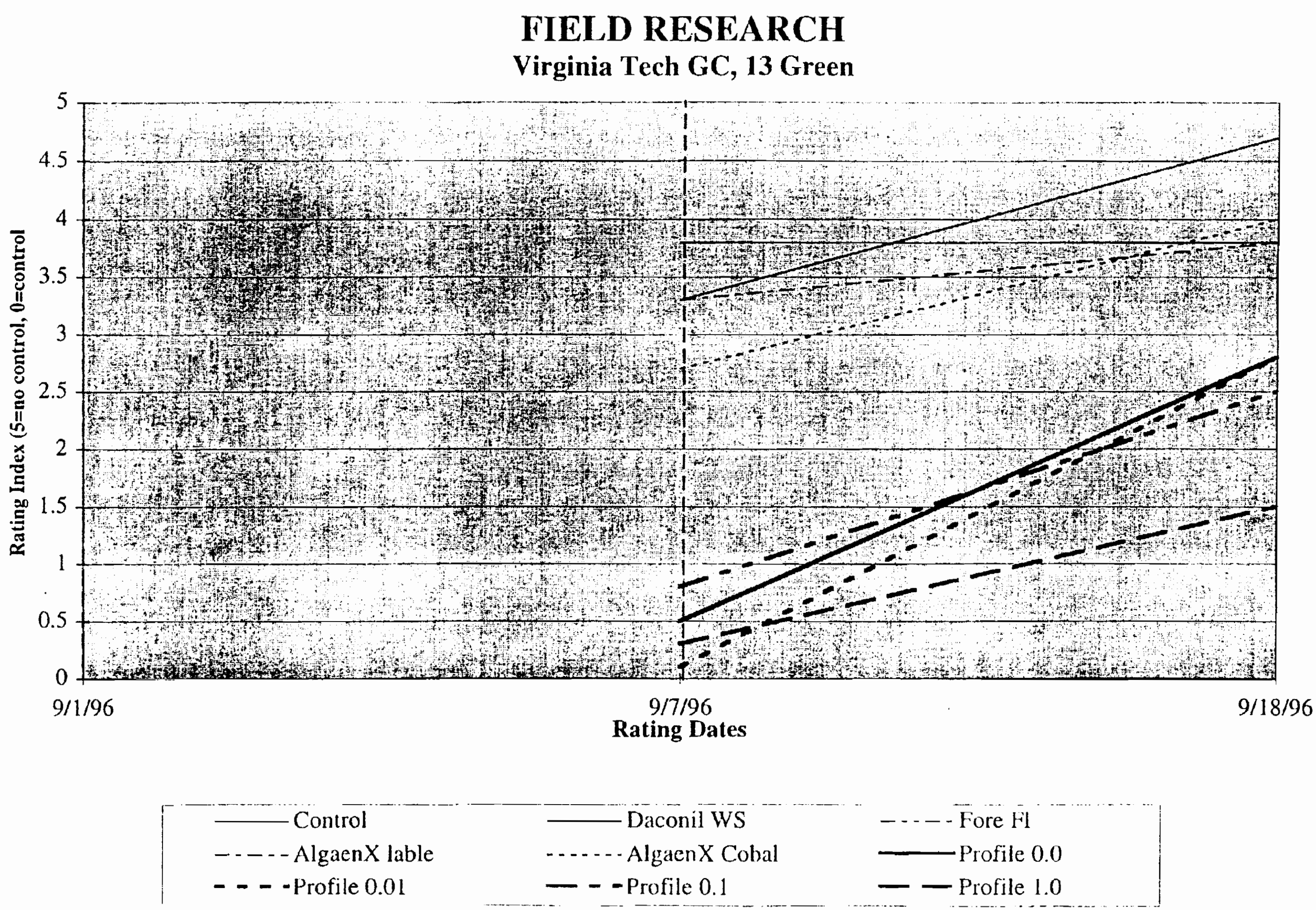

Figure 4. Field results from the 13th green at the Virginia Tech Golf Course. Broken vertical lines represent application dates

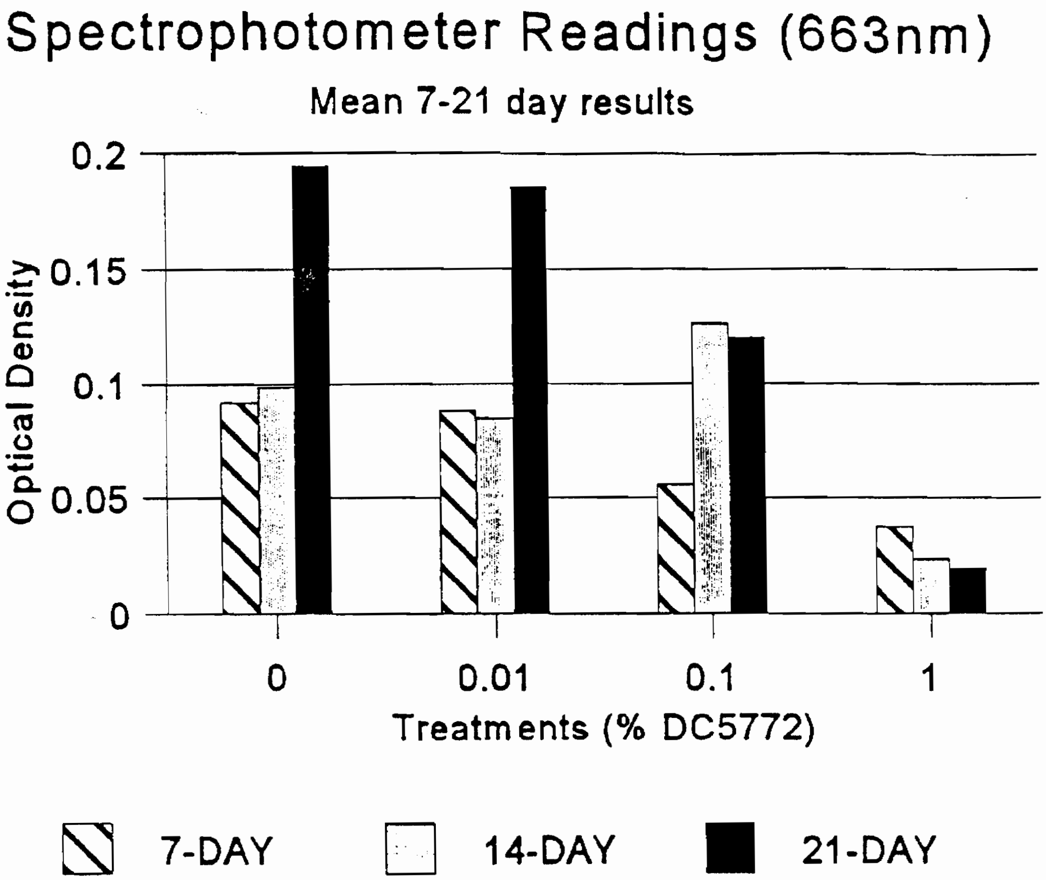

Figure 5. Mean seven to twenty one day spectrophotometer readings.

VITA

The author was born August 1, 1969 in Hindsdale, Illinois. He spent his childhood in New Jersey and graduated High School in 1987.

He has been in the golf course management industry for over 10 years. In spring of 1991 he entered the turfgrass management program in the Crop and Soil Environmental Science Department at Virginia Tech and graduated with a B.S. degree in fall 1994. That same year he entered the PPWS department to pursue a Masters project and report degree in Plant Pathology under the guidance of Dr. Houston Couch. Scott McBane is currently an assistant Superintendent at Galloway National Golf Club in Atlantic City, New Jersey.

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