The Bouyoucos Conference on the Advances in Research on Soil Biological, Chemical and Physical Properties for Sustainable Constructed Rootzones

“Constructed Rootzones 2012”

www.constructedrootzones.org

May 20 – 23, 2012 • Philadelphia, USA

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Welcome!

Thank you for taking your professional time to attend and participate in The Bouyoucos Conference on Constructed Rootzones!

The goal of this conference is to explore the frontiers of recent soil biophysical, biochemical, and hydrological research, and to stimulate an interdisciplinary exchange of research-based information resulting in the development of novel experimental approaches and solutions to develop sustainable performance and productivity standards of constructed rootzones.

The conference will assemble leading agronomy, plant, and soil scientists, with eminent researchers working at the frontiers of soil physics, chemistry and biology to enhance our knowledge of constructed soils; encourage, establish and promote interdisciplinary research collaborations and exchange of research-based information among scientists from academia, government, and industry to pursue, expedite, and transfer advances to the field; develop and explore novel research techniques and methods not normally discussed or considered among plant and soil scientists; and to construct multidisciplinary teams that generate research proposals for governmental agency support in understanding properties and functionality of constructed soil rootzones.

Conference outcomes will include published proceedings and articles, initiation of a global network for the collaboration and exchange of information among applied and basic researchers, and to identify strategies and directions for future research in the area of sustainable, engineered soil-based systems and constructed rootzones.

Enjoy the conference, and enjoy your visit to Philadelphia, USA!

Conference Committee:
John Cisar, Ph.D., Univeristy of Florida
Mike Fidanza, Ph.D., Pennsylvania State University
Stan Kostka, Ph.D., Aquatrols Corporation
Larry Norton, Bayer CropScience
Coen Ritsema, Ph.D., Alterra Research Institute

Honorary Co-Chairs:
George Snyder, Ph.D., Emeritus Professor, University of Florida
Don Waddington, Ph.D., Emeritus Professor, Pennsylvania State University

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Schedule and Program

for the

"The Bouyoucos Conference: Constructed Rootzones 2012"

Summary:	**Sunday (May 20, 2012)** • Welcome Reception
	Monday (May 21, 2012) • Conference Sessions
	Tuesday (May 22, 2012) • Field Trip
	Wednesday (May 23, 2012) • Conference Sessions

Details (for each day):

Sunday (May 20, 2012) - REGISTRATION AND WELCOME RECEPTION

Location:	Omni Hotel at Independence Park 401 Chestnut Street Philadelphia, PA 19106
Time:	5:00 to 7:00 pm

**** See next three pages for Monday (May 21), Tuesday (May 22) and Wednesday (May 23) schedules. ****

Monday (May 21, 2012) - CONFERENCE SESSIONS

Location:	The Conference Center at the Chemical Heritage Foundation - Franklin Room 315 Chestnut Street • Philadelphia, PA 19106
7:30 – 8:00	BREAKFAST
8:00 – 8:15	**Mike Fidanza**. Welcome Remarks.
8:15 – 9:00	**Jim Moore**. Review and historical perspective of the USGA Green Section specifications for golf course green construction.
9:00 – 9:45	**Paul Hallett**. Biophysical constraints and opportunities for constructed root zones.
9:45 – 10:00	BREAK
10:00 – 10:30	**Deying Li** and Lulu Wang. Hydraulic conductivity of rootzone mixtures with high peat to sand ratios.
1030 – 11:00	**Dara Park** and S.B. Martin. Soil surfactant and fungicide influence on soil moisture, disease presence and quality of 'Champion' ultradwarf bermudagrass grown on a USGA specified constructed rootzone in South Carolina, U.S.A.
11:00 – 11:30	N. A. Miller and **Jason Henderson**. Correlating particle shape parameters to bulk properties and load stress at two water contents.
11:30 – 12:00	**Cale Bigelow**. Changes in sand rootzone physical properties and functional performance characteristics from constrasting cultivation and sand topdressing programs.
12:00 – 1:00	LUNCH
1:00 – 1:30	**Richard Rees, Sr.**. Managing stress in turfgrass using chemical intervention and employing techniques for quantitative measurement.
1:30 – 2:00	**Larry Stowell** and Micah Woods. Minimum levels for sustainable nutrition (MLSN).
2:00 – 2:30	**Deying Li** and Lulu Wang. Hydraulic conductivity of rootzones affected by different leaching fraction and salinity component of leaching solution.
2:30 – 2:45	BREAK
2:45 – 3:15	**Mark Carroll**, Yusong Mu and Emy Pfeil. Pesticide degradation in turfgrass thatch.
3:15 – 3:45	**Remi Dreyfus.** Root growth in 2D wet granular media modified by intrusions.
3:45 – 4:15	**Elizabeth Guertal**. Inorganic root zone amendments: effect on putting green physical and chemical properties.
4:15 – 4:45	**Simeon Materechera**. Roots of vetiver grass (*Vetiveria zazanioides*) ameliorates the surface structure of a degraded Hutton soil in a semi-arid environment of South Africa
4:45 – 5:00	**Larry Norton**. Wrap-up and review.

DINNER …….. 6:30 pm, *Buddakan Restaurant, 325 Chestnut Street, Philadelphia, PA 19106*.

Tuesday (May 22, 2012)

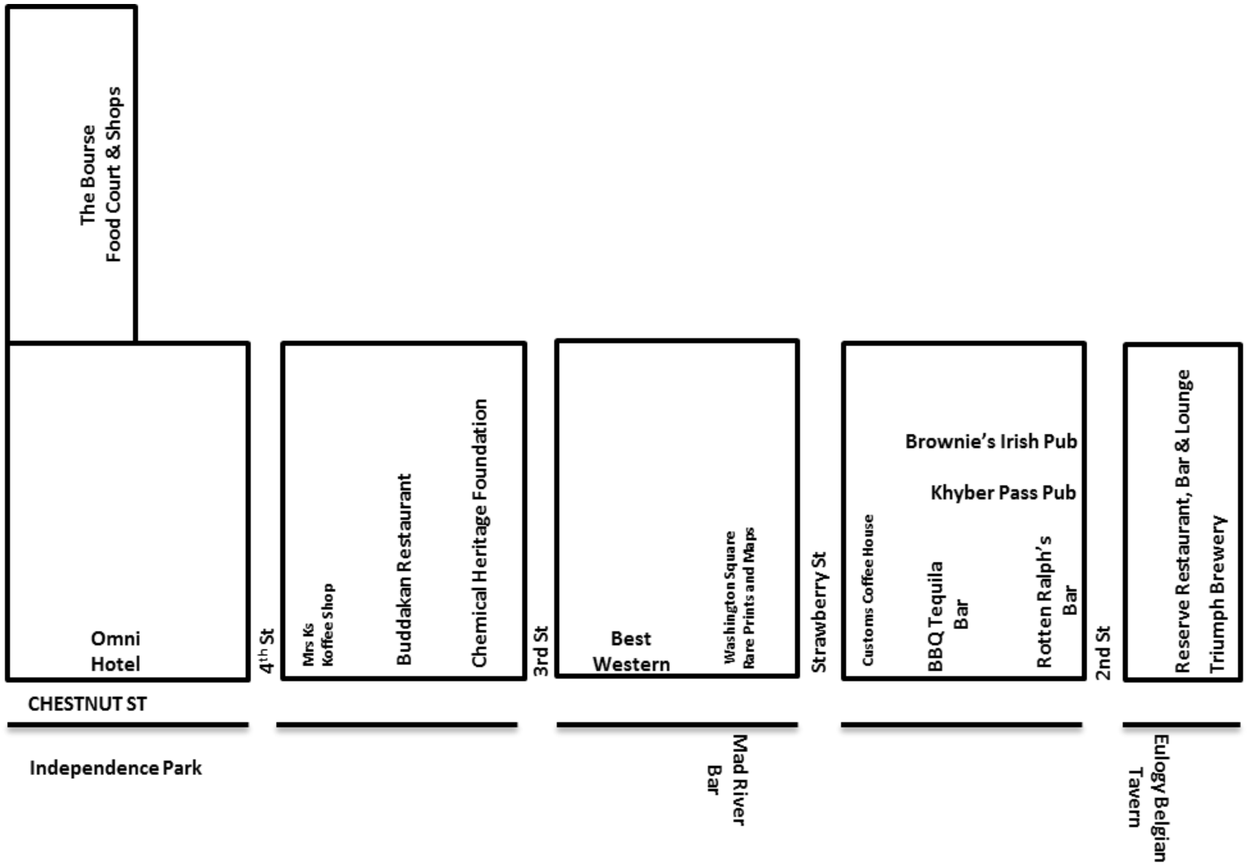
FIELD TRIP

------	BREAKFAST (*on your own*)
8:00	Bus departs from the front of the Omni Hotel at Independence Park (401 Chestnut Street, Philadelphia, PA 19106).
8:30 – 9:30/45	Lincoln Financial Field (Philadelphia, PA); *home of the Philadelphia Eagles*. • **Tony Leonard**, Head Groundskeeper.
9:30/9:45	Depart for next location.
10:15 – 1:00	Merion Golf Club (Ardmore, PA). • **Matt Shaffer**, Golf Course Superintendent. • **Stan Zontek**, USGA Green Section. • LUNCH at Merion Golf Club (** *Clubhouse Dress Code*: no shorts or jeans permitted **)
1:00	Depart for next location.
2:00 – 6:00	Longwood Gardens (Kennett Square, PA). • Greenhouse/soils tour (**Matt Taylor, Casey Sclar** and **Alan Petravich**) • Walk the gardens on your own. • *Early* DINNER Reception, 4:30 – 6:00.
6:00	Depart for return to Omni Hotel.

Wednesday (May 23, 2012) - CONFERENCE SESSIONS

Location:	The Conference Center at the Chemical Heritage Foundation - Franklin Room 315 Chestnut Street • Philadelphia, PA 19106
7:30 – 7:55	BREAKFAST
7:55 – 8:00	**Mike Fidanza**. Conference Update.
8:00 – 8:30	**Cale Bigelow**, Adam Moeller and Jared Nemitz. Soil surfactants and humic acid application affects water retention, repellency and localized dry spot in a sand based rootzone.
8:30 – 9:00	**Andrea Carminati**. Root water update and rhizosphere dynamics.
9:00 – 9:45	**John Cisar**. (1) Development of turfgrass management systems for green roof-type applications; (2) A new inorganic amendment for constructed rootzones; (3) Using plant protectants to improve turf performance and rooting in constructed rootzones.
9:45 – 10:00	BREAK
10:00 – 10:30	**George Snyder** and John Cisar. Monitoring organic matter and other characteristics of golf course greens.
10:30 – 11:00	**Dan Dinelli**. A field trial comparing 20 different rootzone mixes of various organic and inorganic amendments.
11:00 – 11:30	**Joel Simmons**. Mimicking a soil in a soilless medium.
11:30 – 12:00	**Eric Lyons**. How management of plants on constructed rootzones influences root growth and plant competition.
12:00 – 1:00	LUNCH
1:00 – 1:30	**Panayiotis Nektarios**, N. Ntoulas, G. Kotopoulis, E. Nydrioti, D. Barela, T. Kapsali, G. Amountzias, I. Kokkinou and A.T. Paraskevopoulou. Constructed rootzones for green roof systems.
1:30 – 2:00	**Michael Olszewski**, J. A. D'Agostino, and C.M. Verenten. Green roof substrates and their potential effects on plant growth.
2:00 – 2:30	**Matt Taylor**. Compost(able) research at Longwood Gardens.
2:30 – 2:45	BREAK
2:45 – 3:15	**Mica McMillan**, S.J. Kostka, K.E. Williams, J.L. Cisar and T. Boerth. A summary of soil hydrophobicity trials in U.S. Golf Course Greens.
3:15 – 3:45	**John Pope**, Robert Eichenberg, and Tim Birthisel. Use of humate dispersible granule technology as a soil amendment in turfgrass and horticultural soils**.**
3:45 – 4:15	**Derek Settle** and **Mike Fidanza**. Troublesome and emerging turf diseases of golf course greens maintained on constructed rootzones.
4:15 – 4:30	**Stan Kostka**. Wrap-up and review.

Simiplified map of Old City area of Philadelphia.



Conference Venue: ………………………………. **The Conference Center at the**
Chemical Heritage Foundation
Franklin Room (2nd Floor)
315 Chestnut Street
Philadelphia, PA 19106
www.chemheritage.org

Restaurant for Monday (May 21), at 6:30 pm: ... **Buddakan Restaurant**
325 Chestnut Street
Philadelphia, PA 19106
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*** Conference Abstracts ***

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Philadelphia, USA

Review and historical perspective of the USGA Green Section specifications for golf course green construction.

Jim Moore, USGA Green Section

A historical perspective on the development of the USGA Green Section specifications for golf course green rootzone construction will be presented, as well as opportunities to improve and refine construction practices and standards.

Biophysical constraints and opportunities for constructed root zones.

Paul Hallett, The James Hutton Institute

By their nature, constructed root zones are living structures that change over time due to the presence of plants and microorganisms. The impacts include: (i) negative changes in hydrological properties due to the development of water repellency and pore clogging; (ii) organo-mineral complexes that impact nutrient retention; (iii) fluxes in microbial community structure that impact nutrient cycling and plant performance; (iv) the build-up of debris and shifts in plant community structure at the root-zone surface; and (v) the mechanical reinforcement of root-zone soil by the enmeshment of particles by roots and fungi, as well as biological exudates that bind particles. In both horticultural and turf applications, the gradual changes in root-zone performance over time presents a great challenge due to impacts on longer term productivity and hence sustainability.

This talk considers how many of the biological processes described above influence the performance of constructed root-zones. Much of the research draws on experience from agricultural soils and model systems of packed granular media. However, the findings have generic application to constructed root-zones for amenity turf, horticulture and the emerging demands of urban-agricultural production systems.

Pore clogging is demonstrated by a 30% decrease in the hydraulic conductivity of sand by a fungus (*Rhizoctonia* sp.) after 6 weeks of incubation. For a golf green soil, we found that high nutrient loadings induce severe water repellency, which fungal and bacterial biocides suggest are caused by fungus and worsened if competition from bacteria decreases. Management of soil biota to decrease the development of water repellency is a key challenge in constructed root zone design and maintenance. In agricultural systems, mechanical abrasion through tillage is one method to decrease water repellency in the short-term, but research by other groups has shown the gradual development of a stable microbial community structure under zero-tillage may offer a longer-term solution.

Plant roots also have a large impact on changes in the physical behaviour of constructed root zones over time. Depending on the soil, plant and secondary activity by microbes, root exudates can either induce water repellency or act as a surfactant to enhance water capture. We also found that root exudates can initially disperse clays, followed by gelling (aggregation) once transformed into secondary metabolites by microbes. Another large impact of plant roots is mechanical reinforcement of the particle matrix of root-zones. Roots of grasses in agricultural soils can increase shear resistance by over 250% after 5 weeks growth, with even greater impacts found for woody species. We are developing models based on root biomechanics and root-soil interface properties to predict reinforcement effects. Examples of applications of root reinforcement include the enhanced wear resistance of sports turf and the development of soil-free turf.

Hydraulic conductivity of rootzone mixtures with high peat to sand ratios.

Deying Li and Lulu Wang, North Dakota State University

Sand and peat mixtures have been widely used as constructed rootzones in golf course putting greens and sports fields, horticultural potting materials, and in water filtering systems. Water holding and water conductivity of the mixtures are very important properties in those applications. Direct measurement of hydraulic properties often is time consuming. Many models for estimation of hydraulic properties do not include organic matter (OM) content as a predictor. When OM is considered, very often it is treated as clay-sized particles. However, peat and other organic materials used in sand root zone mixtures are fibrous rather than layer-silicates. Previously, a step-wise multi-linear regression model (MLR) was developed to predict saturated hydraulic conductivity (K_{sat}) of sand-based root zone materials from readily available soil properties including bulk density, capillary porosity, clay content, and particle size distribution. However, OM was not significant enough to be included in the model because of the low content. Organic matter tends to accumulate as the sand-based root zones aging and a robust model need to be to be established to account for this fact. Also, horticultural pot mixes and water filtering systems use very high percentage of OM. One of the objectives of this study was to test if the saturated water flow is laminar and obey Darcy's law in a porous medium of sand that conform to the USGA specifications mixed with a wide range of peat content (0 to 25% w/w) and of different peat types (reedsedge, woody sphagnum, and sphagnum). Another objective was to evaluate the test MLR models for sand-based rootzones with a wider range of OM content. The results showed that Darcy's law prevailed in the range of peat ratios used in this study at a hydraulic pressure gradient up to 3. A stepwise MLR model was developed as: $Log_{10}\,(K_{sat}) = 5.0213 - 0.97\rho_b - 1.148CP - 0.0543OM + 0.0872\phi_5 – 0.5743\phi_{10} + 1.1628\phi_{16} - 0.3859\phi_{84} + 0.2323\,\phi_{95}$, ($R^2 = 0.53$), where ρ_b is bulk density (g cm^{-3}), CP is capillary porosity (%), OM is organic matter content (%), and ϕ_5, ϕ_{10}, ϕ_{16}, ϕ_{84}, ϕ_{95} values from the particle size distribution curve for grain size in phi(ϕ) unit. Briefly, ϕ_x = log (2, d), with x representing the percentage of weight passing particle size d in a traditional particle size distribution curve. The model showed a negative correlation between K_{sat} and OM content. This result is in agreement with the pedo-transfer models by Nemes et al. (2005) which include OM as one of the predictors negatively correlates K_{sat}.

Soil surfactant and fungicide influence on soil moisture, disease presence and quality of ‘Champion’ ultradwarf bermudagrass grown on a USGA specified constructed rootzone in South Carolina, U.S.A.

Dara Park and S.B. Martin, Clemson University

Rationale & Objective: In South Carolina, USA, ancillary observations in a fungicide efficacy trial suggested that certain fungicides influenced turf quality and localized dry spot (LDS) development, but warranted further study to quantify the relationship. Surfactants improve turf quality by promoting more uniform water distribution, and presumable more uniform water and nutrient uptake. Indirectly this would be expected to have a positive effect on plant health and disease tolerance. The objective of this experiment was to determine the relationship of commonly used surfactants and fungicides on affecting the longevity of the fungicide response, soil volumetric water content, and turf quality.

Methods: Experiments were conducted during the 2008 and 2009 summers on an USGA specified constructed rootzone research green with established ‘Champion” ultradwarf bermudagrass. Grass was subjected to three treatments of two factors: surfactant (water control, and two surfactants), and fungicide (water control, four fungicides applied as a program, and one single chemistry). Irrigation was maintained at 75% ET with further reductions as needed to induce stressed conditions.

Results: Symptoms of two pathogens were visually determined: *Bipolaris spp.* (leaf blotch) and *Sclerotinia homeocarpa* (dollar spot). In 2008, fungicides influenced disease after the first application with the Program resulting in the least disease severity with Fore having more than the Program, but usually less than the control. In addition, applying a surfactant resulted in less disease than the the water control. In comparison to the the 2008 experiment, disease was documented only twice during 2009. On both dates fungicides and surfactants performed similar to what was found in 2008. Only in 2008 did fungicides consistently influence quality with the program approach resulting in a consistent, higher quality bermudagrass. Both fungicide and surfactant treatments reduced LDS compared to the water controls. Once water stress conditions were induced, soil VWHC was greater in surfactant treated bermudagrass compared to the untreated bermudagrass in both years. Fungicides did not influence soil volumetric water holding capacity.

Conclusions: Applying fungicides did increase turf quality and lower LDS, while surfactants increased turf quality, lower LDS, and increase Soil VWHC. However, with one rating exception, there was no evidence of a surfactant and fungicide interaction to enhance quality, lower disease severity and LDS, or increase soil VWHC.

Correlating particle shape parameters to bulk properties and load stress at two water contents.

Miller, N.A. and **Jason Henderson**, University of Connecticut

Particle shape of prospective root-zone sands is evaluated qualitatively, but a quantitative shape determination may be more useful for sand selection. The objectives of this research were to: determine how particle shape complexity relates to bulk density, total porosity, and mechanical behavior (resistance to displacement given a vertical load); correlate quantitative shape parameters to these properties; determine how water content influences these relationships; and establish if quantitative shape parameters can be used to predict mechanical behavior in the absence of turfgrass roots. Seven materials of various shapes were separated into the medium size class (0.25 to 0.50 mm) to limit variability introduced by particle size distribution. A dynamic, digital imaging machine was used to quantify particle sphericity, symmetry, and aspect ratio. Bulk density, total porosity, and stress at multiple displacements were determined for the materials at two water contents, oven-dry and 5% gravimetric water content. As sphericity, symmetry and aspect ratio increased, bulk density increased and total porosity decreased. Sphericity, symmetry, and aspect ratio were negatively correlated with stress under a vertical load. The addition of water at compaction did not affect the correlations of the shape parameters with either bulk density or porosity; correlations of symmetry and sphericity with these were stronger at 5% water content for some displacements. Multiple regression analysis indicated that sphericity can be used to predict stress characteristics of sands compacted at 5% water content for specific testing conditions. These data indicate that particle shape complexity is related to bulk properties and has potential for predicting the stress characteristics of prospective root zone materials prior to construction.

Changes in sand rootzone physical properties and functional performance characteristics from contrasting cultivation and sand topdressing programs.

Cale Bigelow, Purdue University

Putting green surface firmness and trueness is compromised when excess organic matter (OM) accumulates. This multi-year field study documented the changes in sand rootzone physical properties for a creeping bentgrass [*Agrostis stolonifera* L. *palustris* (Huds.) Farw.] research putting green subjected to five OM management programs: twice annual hollow tine (HT) coring plus heavy sand topdressing with either a medium-coarse sand (HTSM) that matched the underlying rootzone or a medium-fine sand (HTSF), the aforementioned programs supplemented with frequent light topdressing (HTFM or HTFF) during active growth, and a non-cultivated control only receiving frequent medium-coarse topdressing (SAND). Among treatments, the most OM accumulated in the SAND treatment (30.2 g kg^{-1}) compared to the original rootzone (23.2 g kg^{-1}). Adding medium-fine sand resulted in substantial fine sand (0.15-0.25 mm) accumulation at the 0-5 cm depth with the biggest changes with the HTFF treatment. This treatment also resulted in slightly higher in-situ volumetric water contents at the 0-5.7 cm depth and softer surfaces than all other treatments, 0.201 versus 0.184-0.191 m^3m^{-3} and 119 versus 122-134 g_{max}, respectively. Additionally, fine sand additions resulted in decreased infiltration rates and increased moss incidence. To minimize excess surface OM accumulation and maximize functional performance characteristics, like surface firmness, HT coring with sand topdressing should be practiced. Where finer topdressing sands are utilized rootzone physical properties should be closely monitored to avoid unintended negative consequences.

Managing stress in turfgrasses using chemical intervention and employing techniques for quantitative measurement.

Richard Rees, Sr., Bayer CropScience LP

Years of research into the use of chemical intervention for the maintenance of quality in stressed turfgrass often induced by the combination of low mowing heights, suboptimal fertility, high summer heat, and inadequate water availability has led to the discovery of the beneficial properties of certain molecules. When combined, such chemistries provide protection against abiotic stress and allow turfgrass to withstand or recover faster after stressful periods. With the success of these discoveries has come the need to provide quantitative evidence to the regulatory authorities to document the benefits of novel compositions to provide turf managers with tools to assist them in dealing with stressed turf.

Methods have been introduced over the last years to quantify the performance of turf under stress. Techniques to measure photosynthesis, photochemical efficiency, and root function have primarily been employed either in a greenhouse or a lab setting and are used to describe the turfgrass' performance under one type of stressor. In-field measurement of gas exchange has been successfully employed but requires long periods of experimentation under constant conditions and is not conducive to the fast characterization of chemistries that can be employed to intervene in the stress cycle. One non-invasive technique, red and near infrared radiometry has been studied by university and industry scientists alike and this can be used to characterize and quantify stress differences in both fine cut and long cut turfgrass. This has greatly improved the ability to identify novel compositions of stress alleviating chemistries.

Results for novel compositions based on QoI type fungicides such as trifloxystrobin with DMI classes fungicides or a dicarboximide such iprodione applied to turf at rates determined for the prevention of biotic stress also provide the plant with greater ability to withstand the rigours of summer and winter extremes. The use of a fosetyl-AL composition as a preventive treatment for summer decline has been well established in the tool box of the turf manager. For some the underlying mechanisms were not well understood. Results show effectiveness in reducing harmful or excess radiation. Experiments using photochemical methods through fluorescence detection, novel techniques in cuticular transpiration analysis, N^{15} uptake to quantify root function, in-field carbon flux measurements and spectral radiometry have characterized both the turfgrass' reaction and the performance of the compositions to alleviate environmentally induced oxidative stress. The opportunity has arisen, having understood the underlying mechanism of fungicide compositions in alleviating oxidative stress, to introduce new non-pesticide products that address symptoms of transient drought or turf robustness due to lack of available water by acting on the plant rather than just the soil. In conclusion the integration of soil and plant management programmes will lead to a less stressful time for the turf manager.

Minimum levels for sustainable nutrition (MLSN).

Larry Stowell, PACE Turf LLC and Micah Woods, Asian Turfgrass Center

Introduction: Increased economic and environmental concerns have caused many golf courses to re-assess turf management strategies so that inputs and costs are minimized, while golfer expectations are still met. However, there are currently no soil nutrient guidelines that specifically address this growing need. In this study, PACE Turf and the Asian Turfgrass Center pooled soil test data collected over the past 20 years that has all been analyzed by a single laboratory -- Brookside Laboratories, New Knoxville OH. The data was analyzed to determine the minimum level of each key soil nutrient that would sustain acceptable turf growth and quality. The non-negative log-logistic distribution provided a significant fit for all parameters using Kolmogorov Smirnov goodness of fit. The nutrient level that coincides to the 10th percentile (p(x) = 0.1, or 10% of the samples report lower values than x) using the best fit log-logistic distribution was used to define the Minimum Level for Sustainable Nutrition (MLSN) for each nutrient.

Methods: Data for analysis were selected from the PACE Turf database of more than 16,000 individual soil samples. In order to identify minimum nutrient guidelines, only soils with cation exchange capacities (calculated by summation of Mehlich-3 extracted cations) of less than 6 cmol/kg and soil pH between 5.5 and 7.5 were included in the analysis. Olsen phosphorus guidelines were developed for soils reporting a pH greater than 7.5. Data were analyzed using EasyFit distribution-fitting software from Mathwave (www.mathwave.com) and the three-parameter log-logistic distribution was used to identify the MLSN guidelines.

Results: The table below reports the Minimum Levels for Sustainable Nutrition (MLSN) for each soil nutrient, and the values for alpha, beta and gamma for the three-parameter log-logisitc fit provided by EasyFit software.

Method/element[1]	Number of samples	Alpha	Beta	Gamma	Kolmogorov Smirnov (p)	MLSN Log-Logistic p(x) = 0.1
M3 K	1544	2.91	74.20	0.00	0.038	35
M3 P	1517	2.56	45.15	-1.72	0.017	18
Bray 2 P	1538	2.75	54.49	0.00	0.033	25
Olsen P	270	3.25	12.84	-1.11	0.048	5.4
M3 PSI	1409	3.00	0.25	-0.02	0.020	0.1
M3 Ca	1544	71.82	7490.30	-6905.10	0.044	360
M3 Mg	1544	9.02	182.92	-89.54	0.033	54
M3 S	1532	2.37	28.94	1.29	0.030	13
M3 Na	1544	3.01	44.19	0.10	0.042	21
KCl NO_3-N	1133	1.49	2.11	0.00	0.041	0.5
KCl NH_4-N	1133	2.12	2.41	0.00	0.072	0.9
KCL (NO_3-N + NH_4-N)	1113	2.07	4.94	0.87	0.024	2.5

[1] All values are mg/kg unless otherwise noted. M3 = Mehlich 3 extraction; Olsen = Olsen extraction; Bray 2 = Bray 2 extraction; PSI = phosphorus saturation index (M3 P mmol/kg)/(M3 Fe mmol/kg + M3 Al mmol/kg); KCL = 1N KCl extraction and cadmium reduction.

Hydraulic conductivity of rootzones affected by different leaching fraction and salinity component of leaching solution.

Deying Li and Lulu Wang, North Dakota State University

Soil salinization is a global problem threatening the crop production in arid and semi arid irrigated areas. Turfgrass management is facing an even more severe problem because of the increased use of recycled water as a result of portable water shortage. Leaching is an important means of removing excess salts out of the rootzones. The efficiency of leaching practice is affected by many factors, such as water quality, soil types, irrigation, and climate. For non-sodic saline soils, leaching can be achieved using water with the electrical conductivity (EC) below the targeted soil EC based on the plants to be managed. Nevertheless, larger leaching fractions (LR) are required as the EC of leaching water increases. Once the soil becomes sodic, leaching will not be effective because the soil hydraulic conductivity decreases with decreasing electrolyte concentration and increasing sodium adsorption ratio (SAR_w) of the leaching solution, especially for soils high in 2:1 layer-silicates. The objective of this study was to determine the effects of salt composition of leaching solution, EC and SAR_w, and LR on the saturated hydraulic conductivity (K_{sat}) in four constructed putting green rootzones. Three rootzone materials, clay (Fargo series, fine, smectitic, frigid Typic Epiaquerts), clay loam (topsoil model 33441-RDC04, Garick Corp., Cleveland, OH), and sand/peat mixture (90/10 v/v), were treated in a laboratory for 10 saturation/drying cycles with salt solutions at EC_w of 0.2 dS m^{-1} ($SAR_w = 0$) and 11.0 dS m^{-1} (SAR_w =2.5, 5, 15, and 83), respectively. The K_{sat} of those materials then were measured using distilled water. The results showed that sand/peat mixtures were most labile in response to different EC and SAR in irrigation water, the clay loam from Ohio showed some reduction of K_{sat} from the non saline condition, and the Fargo clay showed the most significant decrease of K_{sat} treated with SAR_w of 83 followed by leaching with distilled water.

The three rootzone materials also were used to fill in clear polyethylene tubes (5.4-cm diam., 40-cm height), with the sand/peat mixtures were packed in United State Golf Association (USGA)-putting green style (30 cm of rootzone over 10 cm gravel) and California putting green style, respectively. Therefore, four different rootzone constructions were created. Each tube was supported within an 7.5-cm diameter opaque polyvinyl chloride (PVC) pipe capped on the bottom. Holes were drilled on the bottoms of PVC pipe and plastic tubing to allow for drainage. 'Seaside II' creeping bentgrass was seeded at a rate of 49 kg ha^{-1} in the four rootzone mixtures. Four levels of irrigation in 60, 80, 100, and 120% of the gravimetrically determined evapotranspiration (ET) (equivalent to LR of -0.4, -0.2, 0, and 0.2) were applied using the different leaching solutions mentioned above. The rootzone materials were taken at the end of a three-month growing study from the top 10 cm of the profile and the K_{sat} was measured from the repacked cores using distilled water. The resulting K_{sat} was similarly affected by the EC_w and SAR_w as in the laboratory study, and was not affected by different levels of LR.

Pesticide degradation in turfgrass thatch.

Mark Carroll, University of Maryland

Microbial pesticide degradation within turfgrass thatch is frequently cited as one of the primary processes that hastens pesticide dissipation in turfgrass. The high organic matter content of thatch imparts this medium with dual properties of being able to support relatively high levels of microbial activity (i.e., when compared with soil) while also possessing the ability to readily bind high sorption partition coefficient (i.e., high Koc) pesticides. The former property favors microbial degradation of pesticides while latter may slow the microbial degradation of high Koc pesticides by inhibiting microbial access to these pesticides.

We investigated the degradation of pesticides having contrasting sorptive properties to determine if the extensive sorption of high Koc pesticides by thatch effectively shields these pesticides from microbial degradation. We did this by conducting a laboratory incubation study that examined the aerobic degradation of moderately water soluble flutolanil and nearly water insoluble chlorpyrifos in thatch and soil; and by examining the results of previously conducted thatch laboratory incubation studies that also measured both thatch and soil aerobic pesticide degradation. Pesticide aerobic degradation was assess by comparing the half lives (or degradation constants) of autoclaved and non-autoclaved samples of the same media.

Autoclaved half live was significantly longer than the nonclaved half life in thatch for both flutolanil (87 verses 126 days) and chlorpyrifos (67 verses 82 days). This indicated microbial activity is a significant process in the decay of these two pesticides in thatch. There were however, no differences in the in half life of non-autoclaved thatch and soil for both flutolanil and chlorpyrfios. Our results and those obtained from the literature for high Koc pesticides are consistent with the hypothesis that pesticides which readily partition to thatch are shielded from the microbial populations present within thatch. These results however at odds with numerous field studies that have reported pesticide dissipation in turf systems is usually more rapid that pesticide dissipation in bare or follow soil.

Laboratory incubation investigations offer the opportunity to examine how variables such as temperature, soil moisture, and pH impact pesticide degradation. They suffer however from the inability to regenerate naturally occurring substrates that sustain microbial populations in root infused porous media such as thatch. In the absence of developed methodology to directly measure pesticide degradation in thatch possessing viable roots, laboratory incubation studies will continue to be used to characterize the degradation of pesticides within thatch. There is little concern with this approach when examining pesticides that degrade rapidly. In pesticides that are more persistent, laboratory incubation investigations likely underestimate the microbial degradation capabilities of thatch.

Root growth in 2D wet granular media modified by intrusions.

Remi Dreyfus, Rhodia, Inc.

Plants need water to survive. Several methods have already been used to improve water retention in soils, chief among which is the use of additives such as superabsorbent hydrogels. Although the effects of these chemical additives on hydraulic properties in wet granular media such as soils have already been extensively studied, so far little has been understood particularly on its direct relation to root growth. While also much has been known about water flow in soil, there has been limited understanding of water distribution in the presence of roots. Root penetration in granular media can alter water distribution and how this affects their coupling with common fluxes emanating from soil such as evaporation remains to be understood. Using a controlled visual set-up of a 2D model system consisting of glass beads, experimental investigations on the physics of real root systems has been undertaken particularly on the growth of roots in a model soil subjected to various physical and chemical treatment conditions. Recent results have shown that other inspired solutions can also improve root growth and mortality. Physical intrusions such as a square rod added into the medium can induce preferential tropism of roots deeper into more saturated regions in the soil for greater efficient access to water resulting to a more robust lifetime. These results should gain an understanding of both complex water transport phenomenon and its effect on root growth mechanisms.

Inorganic root zone amendments:
effect on putting green physical and chemical properties.

Elizabeth Guertal, Auburn University

In the last decade the alternative use of inorganic amendments in putting green construction has received much research. Reasons for the incorporation of amendments vary, ranging from improvement in plant-available water holding capacity to increases in nutrient retention. Typically some type of clay, diatomaceous earth, or other porous ceramic, the materials may also be kilned fired to increase their hardness and resistance to wear. Use of inorganic amendments as a substitute to peat in putting green construction has solidified in the industry to the point that their use is now discussed in the USGA guide to putting green construction. Constructed greenmixes that contained inorganic amendments (typical ~10% by volume) have been shown to increase the cation exchange capacity of the green, and increase retention of some nutrients, especially ammonium and potassium. Benefits are most pronounced when the inorganic greensmixes are compared to 100% sand systems. Differences in water retention due to the inclusion of inorganic greensmixes have also been observed, with wide variation in water holding capacity due to sand size, amendment type, and percent of inclusion. This presentation will discuss the various inorganic amendments found in the turfgrass marketplace, and how those amendments differ in their physical characteristics. Existing published literature will be detailed, and gaps in the literature will also be discussed. Last, work at Auburn University that evaluates the inclusion of various amendments in greens renovation programs will also be covered.

Roots of vetiver grass (V*etiveria zazanioides*) ameliorates the surface structure of a degraded Hutton soil in a semi-arid environment of South Africa.

Simeon Materechera, North West University

Most soils used for arable agriculture in the North West province of South Africa are prone to erosion and rapid degradation due to poor aggregation and stability. Due to its extensive fibrous root system, vetiver grass (*Vetiveria zazanioides*) has been promoted worldwide as an effective soil erosion control technology that also rehabilitates the structure of degraded soils. The objective of this study was to compare soil structure in adjacent plots that had been under vetiver grass (VG), natural fallow grass (FG) and on continuous bare ground without vegetative cover (BG) for over 15 years. The total above-ground biomass in the plots at the time of sampling was 5314 and 2186 kg ha^{-1} for VG and FG respectively. The average root length density was significantly higher ($p<0.05$) in the plots with vetiver grass (33.2 cm cm^{-3}) than natural grass (17.4 cm cm^{-3}) and the respective root dry mass were 587 kg ha^{-1} and 217 kg ha^{-1}. Vetiver grass had a much larger root tip diameter (0.41 mm) than natural grass (0.12 mm). Soil structure in the top 0-20 cm of the plots was assessed by measuring physical and biological properties.

The ANOVA showed significance influence of grass species on soil structural properties. The interaction of grass species with soil depth was significant for selected properties. Soil aggregation and aggregate stability as measured by both dry and wet sieving showed large differences between the treatments. The soil under VG had a larger proportion (36.4%) of micro aggregates (< 0.25 mm) compared with that of FG (19.1%) and BG (8.9%). The dry mean weight diameter (DMWD) was greater in BG (8.03 mm) than in FG (6.17 mm) and VG (3.38 mm). Aggregates in BG were the least stable with a wet mean weight diameter (WMWD) of (1.61 mm) compared with those of FG (2.18 mm) and VG (3.89 mm). Similarly, there were a large proportion of aggregates in the < 0.5 mm size fraction after wet sieving in BG (33.2%) compared with FG (12.6%) and VG (5.6%). The reduced stability of aggregates in BG was attributed to the significantly ($p<0.05$) lower organic carbon content of soil in this plot (1.7%) compared with that of FG (1.5%) and VG (3.2%). The aggregates from plots under FG had significantly lower bulk density (1.24 Mg m^{-3}) than those of BG (1.42 Mg m^{-3}) and VG (1.56 Mg m^{-3}). Similar trends of results were observed for the tensile strength of the aggregates. Both the available water capacity and sorptivity measured in the 0-10 cm depth were highest in the plots under VG than the other plots.

There were significant correlations between organic carbon, microbial biomass and most of the soil properties suggesting that improvement in soil organic matter is essential for the enhancement of soil quality in these low clay soils. The increased above-ground biomass and extensive rhizosphere system of VG are considered to be the major inputs responsible for the enhanced soil quality. The larger root tip diameter of VG could be useful in penetrating compact soil and create biopores which may increase the movement of water and gas through the soil. It is concluded that the use of vetiver grass is an affordable and sustainable biological soil management strategy to ameliorate the structure of degraded soils. Other considerations related to the use of vetiver grass for soil management are also discussed.

Soil surfactants and humic acid application affects water retention, repellency and localized dry spot in a sand based rootzone.

Cale Bigelow, Adam Moeller and Jared R. Nemitz, Purdue University

Water repellency frequently develops in sand-based rootzones and can be deleterious to creeping bentgrass (*Agrostis stolonifera* var. *palustris* Huds. Farw.) performance. Soil surfactants (SS) or wetting agents are commonly used to mitigate water repellent soils and localized dry spot (LDS). The effectiveness of various SS to improve rootzone moisture status and relieve LDS is unclear. Prior research has shown improved bentgrass drought resistance when treated with natural organic products like, leonardite humic acid (HA). By contrast, claims have been raised that repeated application of organic products like HA may increase water repellency due to the accumulation of organic coatings on sand grains. A multi-year field study determined the impacts of SS, HA, and SS + HA combinations on volumetric soil water content (VWC), water repellency, LDS and bentgrass appearance. Over the entire study, SS treated turf had significantly higher (0.189 $m^3\ m^{-3}$) surface volumetric water content (VWC) compared to untreated (0.150 $m^3\ m^{-3}$) turf. Both SS and SS + HA reduced water repellency compared to HA alone and the untreated plots at the 0-2 cm depths. The SS alone or SS + HA resulted in slightly better appearance and less LDS than the untreated control. The HA product did not result in any substantial synergistic or antagonistic effects on LDS or bentgrass appearance.

Root water uptake and rhizosphere dynamics.

Andrea Carminati, Georg-August University

Is root water uptake controlled by the hydraulic properties of the soil near the roots – i.e. the So-called *rhizosphere*?

Recent experiments with neutron radiography showed that during drying the rhizosphere of lupins in a sandy soil held more water than the bulk soil. After irrigation the rhizosphere remained temporarily dry and it slowly rewetted after a few days. How to explain such hysteretic and dynamic behaviour of the rhizosphere? And what are the implications for soil-plant water relations?

Our hypothesis is that the observed hydraulic behaviour was caused by mucilage exuded by roots. Mucilage is a polymeric material that is capable of holding large amount of water, but that contains also lipids that makes it hydrophobic when it dries. Here it is proposed a model of root water uptake coupled with shrinking/swelling of mucilage. Water flow is modeled solving the Richards' equation in radial coordinates. During drying, mucilage is in equilibrium with the bulk water and the rhizosphere is at the equilibrium water retention curve. After irrigation, which typically is a quick process, mucilage does not rehydrate immediately and the rhizosphere rewets only partly. The swelling rate of mucilage is driven by the difference between the water potential in the rhizosphere and the potential that the rhizosphere would have at the actual water content.

The calculations reproduce well the observed water dynamics in the rhizosphere. According to this model the rhizosphere conductivity is not univocally determined by the soil water potential, but it is variable and depends on the drying/wetting history. After irrigation, the conductivity of the rhizosphere does not increase as the one of the bulk soil. Such a temporary reduced conductivity may limit the water availability to roots and the water storage in the root zone.

This study shows the importance of the hydraulic properties of the rhizosphere on soil-plant water relations. Hydrated rhizosphere is essential for maintaining soil and roots connected. Irrigation should be scheduled in a way that the rhizosphere does not dry below a critical water content.

Development of turfgrass management systems for green roof-type applications.

John Cisar, University of Florida

With the increasing effort to green urban environments, turfgrass systems provide both intriguing aesthetic and functional benefits for endusers. However, turfgrass systems are not passive, requiring routine management and natural resources to obtain acceptable playing surfaces. In addition, turfgrass systems are typically grown in mineral soil-based systems with appreciable soil depth in excess of 30 cm that provide load –bearing obstacles to roofed systems. Reducing soil depth increases edaphic challenges including increased soil moisture retention that can adversely impact turfgrass performance. This experiment investigated the effect of three depths (0, 5, and 15 cm) of a traditional sand-based construction medium modified with a novel coating of sands to alter cation-exchange capacity and moisture retention for growing sports turf bermudagrass (*Cynodon dactylon* x *C. transvaalenis* Huds.). Turfgrass visual quality, putting green ball roll distance, surface firmness, and soil moisture were determined over two years. Turfgrass visual quality and ball roll were not affected by soil depth. Soil depth affected soil moisture retention and surface firmness. While reduced or modified root zone mixes can provide suitable growing media conditions for turfgrass systems, additional adjustments in management will need to be identified for a range of alternative proposed mixtures and usages. Unique examples of aesthetic and sports turf venues grown on modified substrates will be discussed.

Monitoring organic matter and other characteristics of golf course greens.

George Snyder and John Cisar, University of Florida

A group of USGA-specification ultradwarf bermudagrass greens have been monitored for up to 8 years in south Florida for depths of the thatch and underlying organic-matter stained layers, for the organic matter content and mineral particle sizes of these layers, and for overall saturated hydraulic conductivity. The thatch depth has generally remained fairly constant with time, whereas the underlying organic-matter stained layer usually increased over time. On the average, organic matter in these layers decreased as a result of summer cultivation operations, but increased over the winter when cultivation is diminished or absent. Summer cultivation usually increased saturated hydraulic conductivity, and decreased the coefficient of variation among replicates. A trend for increased sand fineness in the upper portion of the profile has been observed, which likely reduces root zone permeability.

A field trial comparing 20 different rootzone mixes of various organic and inorganic amendments.

Dan Dinelli, North Shore Country Club

A short game practice facility was constructed at North Shore Country Club, Glenview Illinois in the summer of 1997. In addition to it being a functional practice area, the design included various research objectives including field-testing several rootzone amendments in the 7,200 square feet putting green. All rootzones were constructed with the same sand, meeting USGA specifications in particle size and distribution and built to a USGA profile standard. 20 different rootzone mixes were used in cells measuring 14’ x 15’ and 12” deep. A permanent 80-mil high-density polyethylene barrier extending from the top of the pea gravel bed to the surface divided the cells. All plots were seeded with a 50/50 blend of L-93 and SR-1119 at 2 lbs./1,000 sq.ft. A seed blanket was used to assist grow-in and protect from any potential erosion until seedling establishment. All plots were managed equally and topdressed with straight sand as the turf matured. Rootzone cells consisted of: Straight Sand; 85/15 Sphagnum Peat; 90/10 Dakota Peat; 90/10 Dakota Peat plus Chip Humate (250#); 90/10 Dakota Peat plus 22.5% Profile (porous ceramic); 90/10 Dakota Peat plus 15% (v/v) Profile and 350 pounds ZeoPro (zeoponic zeolite); 90/10 Dakota Peat plus 10% (v/v) Zeopro; 90/10 Dakota Peat plus 10% Axis (calcined diatomaceous earth); 90/10 Dakota Peat plus 10% Axis and 350 pounds Zeopro; 90/10 Dakota Peat plus 100 pounds OptiMil (granular Sea Plant Meal and Milorganite with sunflower seed hull ash, total N-P-K of 3-1-4); 90/10 Dakota Peat plus 100 pounds OptiMil and Emerald Isle Microbial *Trichoderma harzianum* and endomycorrhizal fungi; 90/10 Dakota Peat plus 60 pounds SAND_AID (granular Sea Plant Meal, 1-0-1); 90/10 Dakota Peat plus 60 pounds SAND-AID and Emerald Isle Microbial *Trichoderma harzianum* and endomycorrhizal fungi; 90/10 Dakota Peat plus 300 pounds Paramagnetic basalt rock, 40 pounds Hard Rock Phosphate and 40 pounds Greensand; 90/10 Yardwaste Compost; 90/10 Biosolids; 90/5/5 yardwaste/biosolids; Sand mixed with 10 pounds Hydrozone (water absorbing polyacrylamide copolymer); Sand mixed with 5 pounds Hydrozone and earthworm castings; and 90/10 local peat. The results will be presented and discussed.

Mimicking a soil in a soilless medium.

Joel Simmons, EarthWorks

A discussion of how using amendments to mimic a soil in sand based soil environments helped to build over 100 golf course and sports fields. A colloidal soil has a nutrient holding capacity, an organic matrix and a mineral matrix all of which are missing in sand based soil mixes. The use of various soil amendments were tilled into the soil surface to the depth of 6-8 inches showing results such as quicker turf establishment and nutrient stabilization. Physical and nutrient based rock minerals were combined with carbon based amendments to help build up the soils cation exchange capacity and provide a stronger level of nutrient and biological support. Fertilization and water inputs were reduced and turf quality improved.

How management of plants on constructed rootzones influences root growth and plant competition.

Eric M. Lyons, University of Guelph

Constructed root zones provide unique challenges for plant growth in that we often desire to grow species of plants not suited for the conditions of the constructed rootzone. Plant roots evolved to maximize the survival of plants growing in natural soils and often respond in less than desirable ways when grown on constructed rootzones leading to reduced root growth, increased need for foliar fertilization and increased invasion of undesirable species. Nutrient and water availability in sand based rootzones is often limiting requiring frequent applications of both supplemental irrigation and fertilizers. Frequent fertilization events often are applied as foliar fertilizers and there is evidence that this may lead to less desirable shallower rooted species such as annual bluegrass to become more competitive. In addition frequent watering to provide consistent playing conditions on golf course putting greens has created an environment that favors invasive species without roots, leading to an increase in silvery thread moss invasion. The constructed rootzones also may create different nutrient cycling issues within the rootzone that may inhibit the adoption of more environmentally friendly lower impact grasses such as velvet bentgrass by influencing the form of nitrogen available in the rootzone. The inclusion of certain nutritional amendments into the rootzone such as phosphorus bounded to alumina can alter root growth, encouraging deeper root growth. When developing and evaluating constructed rootzones, it is important to evaluate how the management of plants on that root zone may lead to a less competitive environment for the desired species.

Constructed rootzones for green roof systems.

Panayiotis Nektarios, N. Ntoulas, G. Kotopoulis, E. Nydrioti, D. Barela, T. Kapsali,
G. Amountzias, I. Kokkinou and A.T. Paraskevopoulou, Agricultural University of Athens

Green roofs are considered among the best technological solutions for greening existing urban landscapes characterized by the lack of open and green spaces. The selection of the appropriate rootzone (vegetation layer) is of major importance since it needs to comply with several criteria such as: a) providing sustainable growth of the selected plant material, b) exercising limited weight on the building framework, c) providing adequate anchorage depending on the type of the green roof (extensive-intensive), d) consisting of environmentally friendly materials, e) prohibiting any environmental hazards such as nutrient or agrochemical leaching, f) quickly draining excess water yet retaining increased moisture.

Up to date the green roof industry has mainly been following the German guidelines (FLL) for green roofs while other countries have completely or partially accepted them. However the FLL guidelines have been formulated for northern climates and demand alterations for being applicable to semi-arid or Mediterranean type climatic conditions. In addition the formulaic categorization of green roofs as extensive, semi-intensive and intensive has recently received criticisms in an effort to proceed in an adaptive green roof approach that would depend on the local conditions of each urban environment.

Rootzone type, substrate depth and plant species selection are the most important factors contributing to the success and sustainability of a green roof system. The green roof rootzones are mainly constituted by inorganic and at a much lesser degree by organic materials. The most commonly utilized inorganic materials as rootzone constituents are pumice, crashed tile or brick, expanded shale or clay, sand, and zeolite whereas for the organic materials peat and composts.

There is a worldwide research that has provided significant information concerning the effects of different types of green roof rootzones combined with different substrate depths and with various plant species. Several plant species with C_3, C_4 or CAM metabolic pathways have been evaluated and the conditions of their sustainable growth have been determined. It has been acknowledged that rootzone depth has a significant role in green roof flora sustainability since in most cases increasing the rootzone depth has resulted in increasing plant survival and sustainability and contributed to water inputs reduction. Conversely plants have differentiated reactions in regards to rootzone type since they seem to have different inherited preferences for inorganic constituents, organic content and in several cases their behavior has been altered between growing periods (water stressed and unstressed conditions). So far the effort has been focused on utilizing native and endemic plant species to reintroduce the lost flora and fauna in contemporary cities. However there is also an effort to increase the selection palette of plant species by utilizing an adaptive method for green roof construction. In the adaptive approach several plant species categories could be utilized such as turfgrasses, exotic species and other plant species with minimal inputs of natural resources such as water.

The interest of future works on green roof rootzones is to define new materials with a small CO_2 footprint, preferably recycled to be utilized as constituents. In addition the determination of the necessary inputs of natural resources, especially water in the adaptive green roof approach, is imperative in order to support and facilitate decision making processes throughout the world.

Green roof substrates and their potential effects on plant growth.

Michael Olszewski, J. A. D'Agostino and C.M. Vertenten, Temple University

Green roofs consist of overlapping layers that function as waterproofing, root barrier, drainage, substrate, and vegetation. Substrate components are designed to be relatively light weight, to resist degradation, and to drain rapidly. Physical characteristics must meet industry standards (FLL Guidelines, 2002) with water retention determined using 15 x 16.5 cm (diameter x height) cylinders (cyl) containing ~1766.3 cm^3 of substrate. However, green roofs may have a depth as shallow as 4 cm and slopes that affect water-holding properties; thus, a single protocol may be insufficient. Research on green roof physical properties of substrates is lacking. In this study, we evaluated the physical characteristics of a green roof substrate using three different containers. Also, physical characteristics were determined for a preexisting green roof. Particle size distribution was determined by screening using three air-dried 100 g samples of green roof substrate placed into the top of a sieve series with mesh diameters of 9.5, 4.0, 2.0, 1.0, 0.5, and 0.053 mm followed by shaking for three minutes in a Ro-Tap shaker. Physical properties were determined at 0 kPa and following applied suction pressure (6.3 kPa) using methods of Spomer (1990) and FLL (2002). To determine substrate physical properties, Buchner funnels with removable 17 x 16.5 cm-cyl or 13 x 6.8 cm-cyl (diameter x height) were filled with 2835.8 cm^3 or 902.1 cm^3 of substrate, respectively. Bulk density, total porosity (TP), maximum water-holding capacity (~container capacity [CC]), aeration porosity (AP), and $AP_{-6.3\ kPa}$ were determined. A rectangle (rec)-shaped container (~15 x 17 x 7 cm; width x length x height) was filled with 1158.9 cm^3 of substrate directly from an existing green roof (Temple University, Ambler, PA) or from prepared substrate and, subsequently, physical characteristics were determined at an approximate 13.5^o slope. There were three replicates per treatment (container type). Prepared substrate consisted of heat-expanded clay with a composition of 40:50:10 fine grade:medium grade:compost. Temple University's green roof consisted of a mixture of more than one component and has supported healthy *Sedum*, *Allium*, and *Dianthus* genera for several years.

Substrate composition and container shape had a significant impact on physical property determinations. There were no differences for TP, CC, or AP between 17 x 16.5 cm-cyl and 13 x 6.8 cm-cyl or ~15 x 17 x 7 cm-rec. However, TP differed between 13 x 6.8 cm-cyl (TP=38.1%) and ~15 x 17 x 7 cm-rec (TP=45.7%). Physical characteristics on a healthy green roof were 55.8%, 49.6%, and 6.2% for TP, CC, and AP, respectively, and within FLL standards for container capacity. Particle sizes of both prepared substrate and substrate on Temple University's green roof were within FLL standards; however, the later substrate had higher TP and CC than other treatments. Except for short durations following an irrigation event, green roof substrates may be perpetually dry or nearly so. If so, then green roof substrate CC values, and their hydraulic properties, are the key determinant for plant growth. Substrate depth determines the allowable vegetation on green roofs (FLL, 2002) and an accurate evaluation of substrate physical and/or hydraulic properties is vital. In addition to water retention characteristics further testing of substrates may include water potential monitoring using mini-tensiometers, or other moisture probes, and water release characteristics.

Compost(able) research at Longwood Gardens

Matt Taylor, Longwood Gardens

Longwood Gardens in Kennett Square, PA has a strong commitment to sustainability. All organic waste produced on site is either composted or treated and does not leave the property. Longwood's composting facility produces over 3500 cubic yards of compost, mulch and leaf mold per year. In order to use compost and compostable products effectively Longwood performs research in these areas.

Compost as a growing substrate component. Peat moss is the primary substrate component used in the greenhouse industry. The inherent pH of peatmoss can range from 3.0 to 4.0 and is typically increased to a suitable pH with the addition of limestone. Compost is a product that can also be used as substrate component and has a high inherent pH of 6.0 to 8.0. When using compost as a substrate component lime rates must be reduced or eliminated. The objective was to determine the resulting pH of substrates with varying amounts of limestone and compost. The experiment was a factorial design with five compost rates (0, 10, 20, 30, and 40% by volume), four limestone rates (0, 1.2, 2.4, and 3.6 $g{\cdot}L^{-1}$ substrate) with five replications. Three batches of each compost type were tested with this experimental design giving a total of 6 experiments. The substrate consisted of 25% pinebark, 5% calcine clay, 15% vermiculite, 15% perlite with the remaining 40% consisting of peat and/or compost based on the treatments. With 0 lime, initial substrate pH increased from 4.5 to 6.7 as compost rate increased. This trend occurred at all other lime rates, which had pH ranges of 5.2-6.9, 5.6-7.0 and 6.1-7.1 for rates of 1.2, 2.4, and 3.6 $g{\cdot}L^{-1}$ substrate, respectively. These data indicate substrate pH was significantly affected by both compost and lime treatments. Growers who use composts in their substrate mix will have to adjust lime rates accordingly to achieve the target pH.

Properties of biodegradable containers. Biodegradable containers fall into two categories: compostable, which are designed to be removed from the rootball before the final planting and plantable, which are designed to be left intact on the rootball and planted directly into the field, landscape bed or final container where roots will grow through the container walls. Longwood Gardens, Louisiana State University and University of Arkansas conducted research to determine several properties of these relatively new container types, which included peat, Fertil®, Cowpots®, coconut fiber, Strawpots®, OP47, paper, rice hull and plastic (control). Plastic containers had the highest wall strength followed by paper containers, while peat, Cowpot and Fertil containers had the lowest wall strengths. Neither in the greenhouse or the landscape were there any significant trends on growth of vinca, geraniums or impatiens. After 8 weeks in the outdoor beds, Cowpot containers had the highest level of decomposition while Peat, Strawpot and Fertil containers had lower levels of decomposition. Furthermore, cocofiber containers degraded the least. To produce a geranium crop, Fertil and peat containers required the most water and this amount was about double the amount of water compared to plastic. Container strength, biodegradation and water use varied among the different types of biocontainers tested. Fertil, peat and Cowpot containers had wall strengths low enough to make handling difficult and also had higher water requirements. However, these biocontainers were some of the fastest to decompose in the landscape. Depending upon the geographic location, crop, cultural conditions and post production handling, different biocontainer properties will be more or less important. Growers wanting to improve sustainability by switching to biocontainers will need to evaluate which of the properties are the most significant and choose a biocontainer that fits best into their operation.

A summary of soil hydrophobicity trials in U.S. golf course greens.

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Recommendations for golf course green construction have been for rootzone mixes with at least 90% sand while the remainder is typically peat or other organic material. This type of construction mix initially facilitates water movement through the profile but provides an environment conducive to soil hydrophobicity. Several factors such as sand texture, frequent wet to dry cycles, and accumulation of organic matter and thatch contribute to the development of soil water repellency in golf course greens. In research studies conducted over the past fifteen years in several locations across the United States, water drop penetration tests (WDPT) on golf greens have shown slightly and strongly water repellent soil is prevalently found at 0 and 1 cm depths. In the majority of locations, as the depth of profile increased, soil hydrophobicity decreased and was mostly non-existent at the 6 cm depth. These results suggest that despite soil texture and management practices, soil hydrophobicity in a managed turfgrass area is most severe in the thatch and mat area of the profile. While the knowledge of what contributes to water repellency is critical for alleviating symptoms associated with hydrophobic coatings, management practices may be more successful if the focus was on the depth of the repellency.

Use of humate dispersible granule technology as a soil amendment in turfgrass and horticultural soils.

John Pope, Robert Eichenberg, and Tim Birthisel, The Andersons Turf and Specialty Group

Humates and Humic Substances are found in nature and are components of soil humus. Humates function in a wide variety of natural soil processes including chelating of metals, stimulation of soil microbial activity, degradation of organic matter. It has been demonstrated to have soil amending characteristic.

Humic Dispersible Granules (DG) contains four main elements of humate products, HAP, Humic Acid, Fulvic Acid and Humin. All have valuable functions as soil amendments. Humic acid not only stimulates soil microbial activity and is thought to act as catalyst for soil enzymatic activity. It is thought to be essential for plant nutrient in soils. Fulvic acid is a strong chelating agent that can strip metals from salt ions and are especially active stimulating soil microbes when in the presence of a supply of nitrogen.

Humic products available as soil amendments for root zone construction vary in quality and difficulty of use in practice. Humic DG will be examined as a novel form of Humate, beneficial to low CEC soils and in use. Its mode of activity allows Humic substances to self incorporate into soil on application. This is accomplished through patented dispersing technology creating thousands of sub-particles. The dispersed sub particles providing more surface area for Humates to decompose into Humic substance to be available to plant s in these low organic soils.

Troublesome and emerging turf diseases of golf course greens maintained on constructed rootzones.

Derek Settle, Chicago District Golf Association and
Mike Fidanza, Pennsylvania State University

Dollar spot (*Sclerotinia homoeocarpa*), Waitea patch (*Waitea circinata var. circinata*) and fairy ring (many basidiomycete sp.) are considered some of the most common, persistent and troublesome diseases of golf course turf. Golf course superintendents employ cultural practices (i.e., mowing, fertilization/plant nutrition, irrigation/soil moisture management, selection of improved turfgrass cultivars, topdressing practices, soil amendment practices, dew removal and other practices) and fungicide products and strategies to manage turfgrass diseases on golf course greens. Recent attention to an overall plant and soil health approach has warranted research into improving turfgrass disease management programs for golf course greens.

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