

# AXIS RATIONALE

## *Evaluating sand for athletic turf.*

Bingaman, D.E. and H. Kohnke. 1970. Agronomy Journal.

## *Exploring the hydraulic behavior of a USGA putting green soil profile.*

Ganovsky, A.V. and E.L. McCoy. 1993. Agronomy Abstract, p. 158.

## *Rationale for the revisions of the USGA green construction specifications.*

Hummel, N.W.. 1993. USGA Green Section Record, pp. 7-21.

### *Many Greens Don't Wick Properly*

“When considering a USGA putting green soil profile design, many individuals question the need for increased readily available water since the design creates a perched water table at the base of the root zone. This perched water table acts as a reservoir for water storage and subsequent uptake by the turf. Thus, while the root zone mix itself may be droughty, the profile design itself provides the required water storage. For proper operation of this design, however, it is necessary for water stored at the base of the root zone to be able to “wick” to the surface where the predominance of turf rooting occurs.

We have questioned the efficacy of this wicking particularly when highly uniform sands, having narrow pore size distributions, are employed in the root zone mix. Indeed, we have demonstrated via simulation that for soil hydraulic parameters corresponding to uniform sands, this wicking process would fail. (Granovsky and McCoy, 1993). In this case, much of the perched water at the base of the root zone is left untapped while surface soil water tensions simultaneously exceeded 0.1 Mpa (wilting point). Translating this simulation to the real world would imply that irrigation would be applied (required) when there was still a large reservoir of water storage in the profile.

This so-called failure of the putting green profile occurred due to the narrow range of pore sizes (air spaces between the particles) in the root zone mix. Once these pores become air-filled, the hydraulic conductivity of the mix becomes exceedingly low, such that transmission of water from the base of the root zone cannot meet the evapo-transpiration demand of the turf plants.

Conceivably, amending the root zone mix with internally porous, inorganic materials would provide additional water filled pore space and maintain a higher hydraulic conductivity at equivalent soil water suctions. Consequently, these inorganic amendments may afford the means to simultaneously employ uniform sands and ensure proper function of the USGA putting green profile design.”

The incorporation of AXIS, a kiln fired diatomaceous earth product, in USGA-specified root zone mixtures has been shown to increase the ability to manage the sometimes delicate balance of air porosity and water retention in the root zone mixtures on golf greens. AXIS demonstrably makes it easier for water to enter and release from the mixtures. This effect consequently increases the gas exchange potential in the mixture to provide an aerobic condition.

### *Root Zone Mix Testing*

Tests were conducted which measured the effects of AXIS in USGA-specified mixtures. “The increased readily available water was due to the broadening of pore sizes within the mix. The reason for this effect is likely the slightly rounded shape of the AXIS product. Evidence from the literature (Bingaman & Kohnke, 1970) suggests that more rounded sand particles increase total porosity relative to angular sand particles. This increase in pore size distribution would be expected to increase both the readily available water, and water permeability, as the results show.”

### *AXIS compared to Calcined Clay Products*

AXIS differs from clay products in many ways. One of the more significant differences is the larger internal pore structure of AXIS. The vast majority of the pores in calcined clay products are less than 0.1 micron (typical median of about 0.045 micron). In the AXIS product, the majority of the pores are greater than 1.0 micron (typical median of about 0.36 micron). As a result, “AXIS requires approximately 4 times less energy to release water” than calcined clay.

# AXIS RESEARCH SUMMARY – OHIO STATE UNIVERSITY, 1995

## *The Effects of Calcined DE Soil Amendment on USGA Greens-*

Dr. Ed McCoy, Ohio State University, School of Natural Resources. Dr. McCoy serves on the Research Committee of the USGA and is currently conducting water retention research under a USGA grant. Dr. McCoy is a noted soil physicist. *These findings are the result of three years of cumulative research from 1992 with a final report in November 1995.*

### *Root Zone Effects*

Addition of 10% AXIS to the sand/peat blend served to lower the bulk density. This result is expected due to the combined increased porosity of the AXIS materials and their lower particle density compared with sand.

Interestingly, addition of 10% by volume of AXIS to the sand/peat blends served to increase readily available water for both fine and coarse sand blends. The increased available water was due to the broadening of the pore sizes within the mix.

With regard to coarse sand, AXIS provides significantly higher water content near the root zone surface. For the finer sand, however, AXIS provides a slightly drier condition near the root zone surface. In essence, AXIS helps keep coarse sand mixes from becoming excessively dry, and helps keep fine sand mixes from being too wet near the root zone surface. Incorporation of 10% AXIS into a sand/peat blend serves to increase the hydraulic conductivity.

AXIS increases both permeability and readily available water. While increases in both attributes is preferred, this response was not expected since experience suggests these responses to be mutually exclusive.

Amending the sand with peat and AXIS at 10% by volume increased heat capacity by 40%. Higher heat capacity values imply that a soil will warm or cool more slowly for a given heat load provided the thermal conductivity remains unchanged. A much increased water content led to the higher heat capacity.

AXIS increased soil thermal conductivity by 25%. Soil thermal conductivity is a measure of the ability of the soil to transmit heat. Higher conductivity values would allow heat to be transmitted to a deeper depth more rapidly, thus cooling the surface under a given heat load. Alternatively, high conductivity values would allow heat at depth in the root zone to be more readily transferred to the surface.

### *Turfgrass Effects*

Increased rooting was observed for the AXIS at all depths and in both sands. The roots were particularly improved for the coarse sand/AXIS/peat blend at 6-8 inch depths, where they had almost twice the mass of the roots in the coarse sand/peat blend.

AXIS increased plant transpiration. Under drought stress, the sand/peat blend showed higher temperatures than the sand/peat/AXIS treatments. Canopy temperature differential is the difference between the temperature of the leaf surface and the air directly over the leaf blade. A leaf blade that is actively transpiring will have a cooler surface than the atmosphere due to transpirational cooling.

Plant growth is very sensitive to water stress. Clipping yields represent the integrated turf response to drought. Higher clipping yields were observed for sand/AXIS/peat treatments, whereas lower yields were observed for the sand/peat treatments.

Visual differences in turf response to water stress became apparent early in the study. This prompted us to record these observations. Under drought stress the sand/peat root zones yielded higher stress ratings, with the 10% AXIS blend showing much lower stress ratings. Again, this data corroborates all other indications of turf response to drought stress due to root zone composition.

“A compromise between drought response and drainage in a root zone mix must be struck. The use of approximately 10% AXIS added to a moderately coarse or fine sand/peat blend appears to be a reasonable solution to a successful root zone mix.” *Dr. Ed McCoy*

# AXIS RESEARCH SUMMARY – RUTGERS, 2001

## Assessing Root Zone Mixes for Putting Greens over Time under Two Environmental Conditions

J.A.Murphy, J.A. Honig, H. Samaranyake, T.J. Lawson, S.L. Murphy, and B.B. Clarke, Rutgers, The State University of New Jersey  
 Report to the: Golf Course Superintendents Association of America , Tri-State Turf Research Foundation, and the  
 United States Golf Association May 2001

### Amendment Study

It is feasible to amend a sand root zone with a range of materials and produce a putting surface; however, there are noteworthy differences that have implications to management and resource inputs.

AllGro biosolid compost, Kaofin ( recycled paper waste), FertL-soil (spent mushroom soil), AXIS (inorganic) were root zone amendments that provided a turf performance that was similar or better than more widely used peat moss amendments.

Appropriate physical and chemical properties for root zones are still under assessment. However, excellent turf performance has been observed on root zones having a capillary porosity (field samples) of 28 to 37%, and greater N and P availability.

The nutritional improvements (increased availability of P and K) measured in ZeoPro and Profile (inorganic) amended sand appeared to be offset by problems related to droughty conditions.

Amending medium sand with soil at low volume rates (ie. 2.5% and 5%) has produced good turf performance, but management of these plots includes routine hand weeding of plots to remove annual bluegrass. The highest soil rate (20%) has produced unsatisfactory turf under hot dry weather conditions; apparently because of limited soil water availability.

### Turf Quality, Porosity, and Macronutrients

Rank	Amendment Material & Rate (by volume)	Turf Quality Average		Air-Filled Porosity	Capillary Porosity	Total Porosity	N (%) Kjeldahl	P lbs. / acre	K	
		1999	2000	1999 (% vol)	1999(% vol)	1999(%)	1999	---2000---		
( 9=best, >5=unacceptable)										
1	AllGro 20% **	8.6	9.0	8.7	38.4	47.1	0.055	351	14	
2	Kaofin 5%	8.3	9.0	7.9	29.5	37.4	0.015	48	19	
3	AllGro 10%	7.3	8.2	12.8	28.1	40.9	0.018	96	19	
4	Reed Sedge peat 10%	7.3	7.8	10.2	29.9	40.1	0.025	15	15	
5	FertL-soil compost 5%	6.9	7.5	13.6	23.5	37.1	0.015	42	16	
6	Soil 5% on subgrade	6.8	7.4	11.1	25.7	36.8	0.013	46	19	
7	Soil 2.5%	6.6	7.4	11.0	25.4	36.4	0.008	40	18	
<b>8</b>	<b>AXIS 10%</b>	<b>6.8</b>	<b>7.4</b>	<b>12.2</b>	<b>29.3</b>	<b>41.5</b>	<b>0.010</b>	<b>90</b>	<b>27</b>	
9	ZeoPro 10% in surface 4"	6.3	7.4	14.4	24.7	39.1	0.013	86	181	
10	Isolite 10%	7.0	7.3	11.5	27.7	39.2	0.005	50	24	
11	Soil 5%	6.7	7.3	10.7	26.3	37.0	0.018	44	19	
12	Sphagnum peat 5%	7.5	7.2	10.8	27.3	38.1	0.005	26	19	
13	ZeoPro 10%	6.2	7.2	13.6	26.2	39.8	0.013	82	204	
14	Reed Sedge peat 5%	6.8	7.1	11.9	26.4	38.3	0.015	17	13	
15	Sphagnum peat 20%	7.6	6.9	8.5	32.8	40.3	0.010	19	14	
16	Sphagnum peat 10%	7.4	6.9	9.1	29.8	38.9	0.010	20	16	
17	Irish peat 20%	7.2	6.9	9.9	31.0	40.9	0.013	15	14	
18	Irish peat 10%	7.1	6.9	10.3	28.8	39.1	0.020	22	16	
19	Profile 10%	5.6	6.8	12.2	27.8	40.0	0.013	82	55	
20	Profile 20%	5.5	6.7	15.0	28.2	43.2	0.010	104	93	
21	Soil 20%	5.5	6.6	9.8	26.6	36.4	0.025	67	26	
22	None (Sand)	6.8	6.5	10.7	26.0	36.7	0.010	34	22	
23	ZeoPro Plus 10% in surf. 4"	4.8	6.2	16.7	21.8	38.5	0.013	63	345	
24	Greenschoice 10%	3.9	5.5	11.9	26.8	38.7	0.010	65	1	
25	Soil 100%	2.8	4.9	7.8	34.5	42.3	0.190	299	187	

# AXIS RESEARCH SUMMARY – OHIO STATE & PENN STATE, 1998

*Water and Nutrient Retention Properties of Internally Porous Inorganic Amendments in High Sand Content Root Zones.* Edward L. McCoy, Ohio State University, School of Natural Resources. Richard C. Stehouwer, Department of Agronomy, Pennsylvania State University. Journal of Turfgrass Management, Vol. 2(4) 1998.

## SUMMARY

All Internally Porous Inorganic Amendments contained internal porosity that retained water. The AXIS products, however had a larger internal pore space, expressed as a proportion of total porosity, than Profile. Further, the AIXS products yielded a greater increase in this proportion with increased incorporation rate. While peat addition also yielded a large internal porosity, additional increases for sand/IPIA/peat mixes were only observed for the AXIS materials. The AXIS products generally released water from the internal pore space at slightly lower suctions than Profile. At higher rates in sand/product mixes, both AXIS products tended to release water at lower suctions; and in sand/IPIA/peat mixes AXIS XT-1 yielded the greatest improvement in this regard over that of sand/peat alone. Nevertheless, all IPIA's released water from the internal porosity at surprisingly low tensions relative to reported levels of turf response.

Amendment particle sizes and uniformity generally contributed to the saturated conductivity and bulk soil water retention indices for these root zone mixes. For the coarse sand mixes with or without peat, the larger particle sizes and increased uniformity of AXIS XT-1 yielded larger saturated conductivity and generally less negative bulk soil water entry head (smallest soil water suctions sufficient to extract water from bulk soil). Also, the high uniformity of Profile apparently contributed to less negative bulk soil water entry head values but not higher hydraulic conductivity for the same sands. In the fine sand mixes with or without peat, the larger particle sizes of both AXIS products yielded larger hydraulic conductivity values, but there was no IPIA product effect on the bulk soil water retention indices.

Interactions between CEC and K (potassium) selectivity of the component materials contributed to the observed K elution through the root zone mixes. While all IPIA's exhibited K selectivity, only Profile contained sufficient CEC to translate this into selectivity into a K retention response. Thus, the sand/Profile mixes exhibited the greatest delay in K elution from the column leaching experiment. Peat having a much higher CEC relative to the inorganic amendments consequently yielded a high CEC in all peat containing mixes. Yet the sand/peat mix showed only a slight delay in K elution due to the apparent non-selectivity for peat for potassium. Profile addition to the sand/peat blend regained some degree of K selectivity and contributed to CEC resulting in improved K retention in the sand/Profile/peat root zone than in the corresponding san/peat columns. Finally, the internal porosity of all amendment materials did not contribute to nutrient retention under the saturated flow conditions of the column leaching study.

These findings lead to the overall conclusion that diatomaceous earth amendments are better suited to addressing root zone water retention issues whereas calcined clay is better suited to addressing nutrient retention concerns.

# AXIS RESEARCH SUMMARY – PARKS AND OPEN SPACE ASSOCIATION OF JAPAN, 1996

## *International Symposium on Sports Turf and Sports, 1996*

Collected Papers of Symposium Contributors, November 11-12, 1996

Parks and Open Space Association of Japan

Tokyo Electrical Power Company has carried forward the construction of “Japan Football – J Village” which will be the national football training center with a main stadium and eleven pitches in all. It is brought through cooperation of Japan Football Association: J – League, Fukushima Prefecture, and other municipalities. There are 12 pitches, including a stadium, which are high quality, one of which will be artificial turf.

Root zone design is a sand bed design of grain size selected sand in order to keep good drainage, percolation for rainy summer season, and the appropriate firmness of a turf surface suited for football.

Laboratory testing of the sand from Hiron and China was conducted when the sand was supplied. Sand bed design with high drainage capacity is generally believed be adverse to a good microorganism habitat because of minimal water and fertilizer retention. Root absorption of nutrients is low and effective microorganism performance is poor. To make up for these shortcomings, soil improvement material is mixed with the surface layer of the root zone of 20 cm, which equals 7.8 inches.

Calcined diatomaceous earth which is effective for improving water holding is primarily used with peat moss and microorganism matter for fertilizer retention. The guidelines for using each material and the mixing ratio is decided according to test results and root zone guidelines according to the USGA.

As a result of soil improvement material testing, and according to it, the ratio of soil improvement material is crushed stone type of calcined diatomaceous earth, **AXIS**: 10%, powder peat moss: 5%, and microorganism matter, 1%.

### *Targeted Properties*

Category	Desired Value	USGA Standard (Reference)
Permeability Coefficient	1.0 x 10 cm <sup>3</sup> or more	0.4 – 1.7 x 10 cm <sup>3</sup>
Water Holding Capacity	20% or more	12.0-24% (weight)
Available Water Content	10% or more	----
pH	6.0 – 7.0	5.5 – 8.0

### *Results of Soil Improvement Examination*

Material	Type	Mixing Ratio	Permeability Coefficient	Water Holding Capacity	Available Water Content
Inorganic	AXIS	5%	3.9 x 10 cm <sup>3</sup>	17%	9.1%
	<b>AXIS</b>	<b>10%</b>	<b>1.9 x 10 cm<sup>3</sup></b>	<b>20%</b>	<b>9.6%</b>
	Isolite	5%	3.0 x 10 cm <sup>3</sup>	18%	9.6%
	Isolite	10%	2.5 x 10 cm <sup>3</sup>	18%	8.5%
Organic	Peat moss	3%	1.3 x 10 cm <sup>3</sup>	18%	8.5%
	Peat moss	5%	1.4 x 10 cm <sup>3</sup>	15%	7.3%

# AXIS SELECTED INDUSTRY ARTICLES

## Golf Course Management, July 1995

*"Giving Greens a Second Chance." By David R. Pease and Ron Luepke,*

*General Manager of Golf Courses, Monmouth County, New Jersey & Superintendent of Monmouth County Hominy Hill Golf Course.*

The tremendous demand for golf in Monmouth County, N.J., has been putting increasingly severe stress on the turf of its four public golf courses. As with many courses across the United States, the soil in many of the putting greens is inherently far from ideal, and with the number of rounds soaring each year, compaction has been an ever increasing problem.

When the county acquired the courses in the mid-1970s, conflicting soil management programs had resulted in extensive soil problems. Therefore, we needed to treat compaction and enhance the soil structure within the greens by increasing capillary pore space within the root zone and increasing the plant-available water.

We looked at these Diatomaceous Earth soil amendments as soil/water management tools with anti-compaction properties. After attending lectures and consulting with numerous soil scientists about the effects, credence was given to the benefits of increasing capillary pore space with the use of these materials.

We first used the amendment as a topdressing ingredient for filling holes after aeration on localized dry spots and walk-off areas. The intent was to improve the soil physical characteristics, such as permeability, porosity, and water retention and availability. Next, we extended our use to high-traffic areas on certain greens to relieve the effects of soil compaction. Then we initiated an intensive aerification program consisting of double-aerifying the greens to modify the root zone mix.

The results were noteworthy. The straight sand amended greens showed improved percolation and rooting. However, we also noticed hydrophobia. The 50/50 sand/DE amended greens showed better rooting, eliminated dry spots and delayed wilting. In addition, the treated greens showed less stress overall and significant turf improvement on the heavily used walk-off areas.

Next we built two greens, one was constructed with 85/15 sand/peat ratio as recommended by the lab. The other green was built with the same sand/peat ratio, but on half of that green we added 10% calcined DE amendment to the top 12 inches of the root zone (77/13/10 sand/peat/DE)

Soil mix Hominy Hill #8	Bulk	Capillary	Non-Cap	Total	Water	Water	Water	Infiltration Rate (inch/hr.)	Available Water	
	Density g/cc	Pore Space %	Pore Space %	Porosity %	Hold. Sat.	Hold. 1/10 B	Hold. 1/3 B		Sat-1/10B g/cc	Sat-1/3B g/cc
Before DE	1.68	16.57	16.29	32.86	19.52	9.84	4.62	8.66	0.16	0.26
After DE	1.37	22.13	21.01	43.14	31.53	16.17	10.23	7.76	0.21	0.29

The split-green experiment showed greater water retention in the areas treated with the calcined DE amendment. Drought symptoms such as wilt also seemed to be delayed. Although root depth appeared similar on both sides, the side treated with the DE amendment showed greater root mass, with a tremendous amount of root hair production. Root weights from each side were not compared, but visually it was clear that more root mass was present in the DE-amended half. It was also apparent that nutrients were held much longer, with less leaching within these high sand mixes. The need for frequent nitrogen applications during grow-in of these areas was diminished, which, in our opinion, was due to the increased cation exchange capacity provided by the calcined DE amendment.

What we have seen by these amendments is extremely promising. If we can gain two or three days in delaying the wilting of localized dry spots, our hand-watering and syringing practices could be kept to a minimum. The additional capillary water gained by using these amendments has shown to be cost-effective, with less time spent watering and less water being used. In addition, fewer nutrients are being applied on the new grow-in areas. The root mass associated within the aerification holes indicated an improved soil structure, specifically in regards to the air/soil relationship, encourages better root development, which in turn helps ward off root-borne pathogens.

In our opinion, the cost savings justifies the additional expense of incorporating these DE amendments into our topdressings and topmix profiles. The previously mentioned indicators show a positive effect within the greens' root zones.

# AXIS SELECTED INDUSTRY ARTICLES

California Fairways, July/August 1996

“Topdressing and Aeration Strategies.” By William A Mannion,  
Ph.D. in Chemistry, Consultant, San Rafael, CA

Sand is the accepted inorganic amendment because it's hard and drains well and also because it's inexpensive and widely available. But sand doesn't hold much water and has almost no nutrient-holding capacity. There are inorganic alternatives to sand that hold substantial amounts of water and provide Cation Exchange Capacity (CEC). They are also hard and drain well. The ideal application of inorganic soil amendments is to achieve a uniform ten percent volume in the soil mix because that ensures that every sand particle touches a particle of amendment.

The results are extraordinary. University research shows that incorporation of AXIS, for example, at ten percent by volume nearly doubles plant-available water and improves hydraulic conductivity by 50 percent. By comparison the addition of peat barely affects plant available water and compromises long-term compaction resistance. The amendments translocate water and nutrients into the soil profile and encourage deeper rooting by the plant. The steady availability of water and nutrients in the profile is especially important during hot periods because it reduces the stress on the plant which otherwise will slough off roots when water isn't available.

Inorganic amendments (besides sand) may be classified as diatomaceous earth (d.e.), clays or zeolite. Each is a distinct mineral as reorganized by the U.S. Bureau of Mines. All of these minerals are mined and processed to varying extent. Chemically, d.e. is the most like silica with minor amounts or alumina. Table 1 summarizes chemical and physical properties of these three types of soil amendments. Note that water absorption and CEC are compared on a weight basis and on a volume basis. Properties for sand and sand with ten percent peat by volume are also listed in Table 1. Note that water absorption for each amendment is much more than sand or sand plus peat. Research on plots amended with ten percent d.e., for example, show substantially more resistance to drought than peat amended plots.

Table 1 \*  
Physical and Chemical Properties of Some Commercially Available Soil Amendments

Amendment	Bulk Density	Water Absorption		CEC	
	Lbs. / cu. ft.	Wt %	Lbs./cu.ft.	meg/100g	meg/liter
Sand	90	6	5	0.08	1
Sand + 10% Peat	85	7	6	1.3	16
Diatomaceous Earth	26	142	37	27	110
Clay	37	90	33	33	240
Zeolite	50	60	30	100	880

\* Revised to reflect current Manufacturer's Information

These amendments also improve the exchange capacity because sand is so sterile. Both clay and d.e. provide about as much exchange capacity as peat on a volume basis and they resist compaction. A CEC of 15 meg/liter of soil is usually enough to absorb the nutrients applied during fertilization, e.g. one pound of N per 1000 square feet delivers about 3.4 meg N/liter of soil into the top four inches of soil. However, when very hard water is used for irrigation, nutrient leaching will be quite severe. In this case higher exchange capacity will help retain nutrients in the rootzone instead of the current practice of using slow release fertilizers.

## So, How Much Do They Cost?

More than sand, sometimes much more, depending on local availability of good quality silica sand. The higher price reflects costs for mining, processing, quality control and freight. Depending on bulk density, two to four times as much sand is needed to topdress the same square footage of green. Table 2 compares material costs on a weight and volume basis for the amendments alone and for sand plus ten percent of the amendments. In the latter case the costs are quite comparable; \$1.50 per cubic foot for sand with ten percent amendment, versus \$1.30 per cubic foot for sand with ten percent peat.

**Table 2 \***  
**Estimated Materials Cost for Some Commercially Available Soil Amendments**

Amendment	Bulk Density	Material Price	
	Lbs. /cu. ft.	\$ / ton	\$ / cu. ft.
Sand	90	15	0.70
Diatomaceous Earth - Regular	25	500	6.25
Diatomaceous Earth - Fine	26	700	9.12
Clay - Coarse	37	360	6.66
Clay - Fine	41	500	10.25
Zeolite	50	500	12.50
Peat	15	900	6.75
<b>Mixes</b>			
Sand + 10% D.E.- Regular	85	26.05	1.17
Sand + 10% D.E. - Fine	85	32.75	1.47
Sand + 10% Clay - Coarse	86	26.88	1.21
Sand + 10% Clay – Fine	86	34.80	1.57
Sand + 10% Zeolite	87	39.80	1.79
Sand + 10% Peat	85	27.18	1.22

\*Revised to reflect current market prices.

Greens in decline will need aggressive action. It may be necessary to double core-aerify and topdress with 50/50 by volume amendment/sand to arrest the decline and then continue with a lesser treatment for subsequent aerifications. Many superintendents report their greens heal more quickly and are playable sooner after topdressing with one of these amendments versus their experience with straight sand – ten days for complete healing versus 14 days for sand. Superintendents also report less damage to greens mowers because the amendments are less abrasive than sand.

In 1982 a new superintendent began using d.e. to amend greens that were “in decline on a championship course that had gone downhill” and within four years had brought them back better than new with a “top 75 public course nationally” rating to prove it. He has continued to use d.e. and for the past several years has added some zeolite with good results. He hasn’t used a “cupful of sand” on his greens the past 12 years.

Inorganic soil amendments are practical and effective additions to improve the performance of golf course greens. They resist compaction, promote good drainage and translocate nutrients and moisture deep into the profile. The turf is healthier, withstands stress better and requires less syringing of ‘hot spots.’

# AXIS PROFESSIONAL TESTIMONIALS

“Congratulations on a great product! Seeing is believing. As part of a grow-in, the establishment of greens is imperative, and AXIS has now become an integral part of our program. We applied AXIS Fine to a green to test the effectiveness as a topdress. We applied it at 100 pounds per 1,000 square feet; we then seeded directly into it. The results were astounding. The establishment was much quicker than we had ever expected. In comparison to the greens that didn’t have AXIS applied, the establishment and uniformity was at least two times better. From this point on we will be using AXIS on the remainder of the greens at Stone Creek Golf Course as well as recommending it on future projects. As a topdress AXIS is a slam-dunk. It is cost effective and easy to apply. If the results are this good as a topdress I can only imagine what it could do as a root zone amendment. Thank you for bringing this product to the market. You have a winner!”

Peter Jacobsen – Professional Golfer and Golf Course Designer  
Oregon City, OR

“We have used AXIS in many applications and we have found that it improves drainage, resulting in less downtime and damage on the fields due to rain. Due to the water holding capability and non-compactable pore space of AXIS we have found that it helps reduce soil compaction and helps improve the resiliency of the soil, resulting in a surface less prone to player injuries. Other areas where we feel AXIS has helped us include the “grow-in period” where we have improved establishment of sod and seed. Our intentions are to continue to use, and to recommend the use of AXIS for sports field modification.”

Bob Hummer, Hummer Turfgrass Systems, Inc.  
Lancaster, PA

“Straight sand will give you an infiltration rate of 17” per hour. That jumps to 23.8” with 12% AXIS. The interesting thing is water holding capacity also increases, which is opposite to what you might expect. While water holding capacity at saturation with straight sand is 21%, adding AXIS to the mix increases it to 26%. The practical benefits are many. After 3” rain, these greens are ready to be played or mowed in 15 minutes. I have gone as long as a week without irrigation, due to the better water holding capacity. I really haven’t watered these any more than I would have a standard push-up green. There is also an increased oxygen diffusion rate. The soil just breathes better.”

John Roedell, Superintendent, Chesapeake Bay Golf Club  
North East, Maryland

“I originally purchased AXIS to help improve air and water movement in 3 of my poor greens. I applied the AXIS to these three greens after aeration. I used approximately 20 bags of AXIS for a 6,000 sq. ft. green. As the season went along I was very pleased with the performance of the product. My normal water cycle on greens is approximately 20 minutes. The 3 greens I applied AXIS to have cycle times of approximately 12 minutes in peak heat days. I noticed when I was changing holes that the roots of our Poa Annua greens have AXIS particles clinging to the roots. I also noticed that the roots were denser and longer. I was able to achieve approximately 5” roots when the rest of my Poa Annua greens were approximately 3” last August. As you know Poa Annua is a shallow rooting turf to begin with. This has been one of the worst years for Fusarium Patch. Our greens have approximately 20% coverage by Fusarium Patch. Two of the AXIS greens have approximately 5% coverage and one of our greens is free from disease. I also noticed this in the summer months when we are fighting Anthracnose. I can only attribute this to a healthier environment. I now incorporate AXIS during my regular aeration schedule approximately 4 bags per green per aeration twice a year. I feel if I can reduce my fungicide applications each year and reduce my water consumption AXIS almost pays for itself. Most of all I am providing a healthier product.”

Brian Youell, Superintendent, Uplands Golf Course  
Victoria, B.C.

Al Kline began using 100% Dialoam as a topdressing on the (University of New Mexico) Golf Course in 1980 because available sand had a high pH (8+). This course has pushed up greens with no subsurface drainage. In addition to modifying the soil structure, Al began to manage his irrigation system intensely. As a result, he has changed his heads from 45 gpm to 35 gpm and his run time from 25 minutes to 12 minutes with no syringing even in the hottest weather. Reducing watering by better than 60% has created secondary savings in fertilizer, pesticides and herbicides.

Al Kline, Superintendent, University of New Mexico Golf Course