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# Genetic Characteristics and Environmental Parameters for Growing Turfgrass in Closed and Retractable Dome Stadiums

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- **Genetic Characteristics and Environmental Parameters for Growing Turfgrass in Closed and Retractable Dome Stadiums**  
Bruce Bugbee and P. Johnson

### INTRODUCTION AND SUMMARY

*Our analysis indicates that electric lighting for turfgrass growth is highly cost effective, if it is coupled with appropriate genetic and environmental changes.*

Inadequate light levels for vigorous turf growth is the key challenge associated with growing turf in enclosed and retractable dome stadiums. The light levels of closed stadiums are too low to maintain vigorous plant growth that can quickly recover from the damage caused by athletic events. As a solution, retractable-dome stadiums have been built. However, even with the roof open, light levels in these stadiums are less than half of natural sunlight because of shading from the side walls of the stadium. As such, maintaining an attractive, uniform playing field has been difficult.

Vigorous plant growth without sunlight is routinely achieved in commercial hydroponic lettuce and tomato production using electric lamps. This same technology can be used to maintain live turf grass in closed athletic stadiums. It can also be used to supplement natural sunlight in retractable roof stadiums. The challenge is to determine the optimal combination of genetic characteristics and environmental parameters to grow turf in a closed stadium using artificial light and to quantify the benefits of supplemental lighting in retractable dome stadiums.

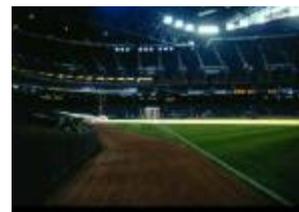
The research and development needed to achieve vigorous turf growth under the low light conditions of enclosed and retractable dome stadiums can be accomplished in four phases, which include:

- Develop stadium design requirements for vigorous turf growth in enclosed and retractable dome stadiums based on a thorough feasibility study of current state-of-the-art for turf production in low light.
- Quantifying the response of the two most promising turf grass species (*Zoysiagrass* C4, warm temperatures or *Poa supina* C3, cool temperatures) to low light and determining the value of growth regulators, CO<sub>2</sub> enhancement, temperature, etc. for enhancing growth under low light.
- Examine all promising turf grass species and the genetic variation within each species to enhance vigorous turf growth under ever diminishing light levels (10 to 1 mol m<sup>-2</sup> d<sup>-1</sup>), and initiate preliminary evaluation of turfgrass species and critical levels of secondary inputs (i.e., growth regulators, CO<sub>2</sub>, temperature, nutrients, etc.) in stadiums.
- Implement full-scale testing of turfgrass on indoor athletic fields in direct collaboration with stadium engineers and field managers.

Following we review the current state-of-the-art for turf production in low light and discuss in detail the research needed to achieve healthy, live turf on indoor playing fields.

### STADIUM TECHNOLOGY AND TURFGRASS MANAGEMENT ISSUES

The management of live grass on athletic fields presents an extraordinary challenge to plant physiologists. Athletic fields are regularly damaged by intense activity and are expected to continuously look as good as artificial turf. TV exposure, demands of coaches, and high salaries of professional athletes all contribute to high expectations. These same fields are also often used for other events such as music concerts and other revenue generating activities for the stadium. These many demands, combined with the desire to attract more fans to sporting events, have created many changes in stadium field technology.



### Artificial vs. Natural Turf

Artificial turf was extensively used in stadiums until about 10 years ago to reduce maintenance and increase the use of a venue. However, many outdoor fields are now being converted to natural turf, and most new stadiums are installing natural grass fields. Natural turf fields provide cooler playing conditions, and provide psychological benefit to both players and fans. The spectator experience has become a critical part of stadium design in recent years. Camden Yards in Baltimore and Jacobs Field in Cleveland are shining examples of spectator stadiums. Part of this experience is the natural grass.

Even more importantly, natural grass offers a safer playing surface for athletes. Natural turf is usually softer than artificial turf and protects joints and muscles from damage. A recent survey of NFL Players found that 92% believe playing on artificial turf leads to shortened careers, 90% feel that artificial turf will worsen their quality of life after football, and 96% say that artificial turf adds to their soreness after games. Natural turf is softer and offers more give than artificial turf. When a player turns quickly, their cleats tear at the turf. If the strain is too great, the turf gives way. This feature is much like a shear pin protecting a motor on a piece of equipment.

Natural turf has many benefits but requires high light levels for good growth. Artificial turf has thus been the only choice for domed stadiums.

### Stadium Technology

The Houston Astrodome, built in 1965, demonstrated that domed stadiums could prevent weather-related delays and cancellations of events. Domed stadiums are now popular around the world, but the surroundings are considered sterile, partly because of the artificial turf. Turfgrasses can be grown in many stadiums, but the light levels are too low to maintain vigorous plants that can recover from the damage caused by athletic events. As a compromise between domes and open-air stadiums, retractable-dome stadiums are now being built. The first retractable dome stadium was the SkyDome in Toronto, built in 1989. The Skydome provided an open air feeling, potential to use real grass, and prevented weather delays. Numerous retractable dome stadiums are now being built worldwide. These include Safeco Field in Seattle (opened July 1999), Miller Park (under construction), Enron Field in Houston, and fields in Japan (Oita Sports Park, and the Sapporo Dome). In fact, retractable-dome stadiums are being proposed and built in the hope of attracting a professional sports team. The Harris County Stadium is being proposed to attract a football team back to Houston Texas.

The first retractable domed stadium to use natural turf is the BankOne Ball Park in Phoenix, Arizona. This field has been in use for two seasons. In spite of the retractable dome, low light conditions limit the growth and durability of the turf, especially if post-season baseball games are played into October. These problems would be exacerbated in more northerly areas where the dome would be closed more often due to weather, and there would be greater shading due to the lower sun angle.

To further add to the reduction in light, the roof at BankOne Ball Park has been closed more than originally planned because of the priority for fan and player comfort. Thus far, retractable-dome stadiums have only been used for baseball. Football presents a new challenge, especially where the roof would likely be shut the majority of the time to facilitate heating during the cool fall weather.

### Unique exceptions

A unique combination of natural turf and a domed stadium was used during the 1994 World Cup soccer games played at the Pontiac Silverdome in Pontiac, Michigan. The Silverdome has a fabric roof and has an artificial grass field. Prior to the World Cup, turf was grown in large interlocking containers that were moved into the stadium for the games. These containers were then moved out after the events. The turf was in the stadium for up to 10 days at a time and provided a high quality playing field for the matches viewed around the world. In a similar and even more temporary situation, thick rolls of sod were laid on the floor of the Louisiana Super Dome for a football game and removed shortly after the game.

To date, no stadium has successfully grown natural turfgrass for extended periods in a completely enclosed stadium with a roof that does not transmit sunlight. Even retractable dome stadiums have inadequate light levels for vigorous turf growth.

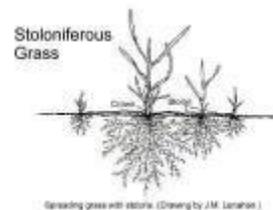
The challenges is to determine the optimal combination of genetic characteristics and environmental parameters to grow turf in a closed stadium using artificial light and to quantify the benefits of supplement light in a retractable dome stadium.



### GENETIC CHARACTERISTICS OF TURFGRASS SPECIES

*A "start with the grass" approach will improve chances of successfully engineering enclosed turfgrass stadium fields.*

The most commonly used turf in cool-season athletic fields (northern half of the U.S.) is Kentucky bluegrass (*Poa pratensis*). Bermudagrass (*Cynodon dactylon*) is the most commonly used turf in warm-season athletic fields (southern half of the U.S.). However, neither Kentucky bluegrass nor Bermudagrass are tolerant of low light levels. The grass species most tolerant of low light levels are *Poa supina* and zoysiagrass (*Zoysia japonica*). These two speices have excellent potential for indoor stadiums.

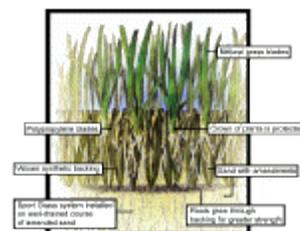


*Poa supina* is relatively new to the U.S. turf industry. It has been studied for use as an indoor athletic turf in translucent roof stadiums and has been consistently the best performing cool-season turfgrass in those conditions.



It is very useful on athletic fields because it has aggressive lateral growth by stolons, which helps it recover from athletic damage. One of the first aspects of growth impacted by low light is lateral growth and damage recovery.

*Zoysiagrass* is used extensively in the southern U.S. for lawns and athletic fields. *Zoysiagrass* grows slowly, but is rugged and resistant to damage because of an extensive network of underground stolons. It also is one of the most shade-tolerant of warm-season grasses. *Zoysiagrass* was used at the Bank One Ballpark in Phoenix, Arizona because of its ability to tolerate the hot summer temperatures yet still survive in the shadiest areas of the stadium. It is well adapted to the warm, humid conditions.



Although both *Poa supina* and *Zoysiagrass* are classified as shade tolerant, there is very little quantitative data on the low-light level limit, how other environmental factors affect low-light tolerance, and most importantly, the wear tolerance characteristics.

### Types of wear

Three general types of damage occur on athletic fields.

- Abrasion damage is present most anywhere the turf is used.
- Divots, or tearing of the turf, are the most common. Athlete's cleats tear the turf and remove part of it leaving a divot or void.
- Soil compaction in the most frequently used areas of the fields. Compaction can be greatly reduced by management practices and proper field construction.



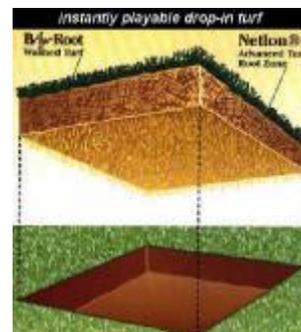
Both *Poa supina* and *Zoysiagrass* are tolerant to abrasion and both resist or repair divots. Additional methods of replacing large areas



of turf and supplementing the surface soil with plastic fibers can also increase tolerance to tearing wear using currently available technology (See below: Supplemental management and construction techniques).

### Research methodology to determine wear tolerance

A number of methods have been developed to simulate wear on turfgrass plots. These methods usually involve pulling a unit with two drums with numerous cleats or spikes inserted. The two drums turn at slightly different rates causing a tearing action on the turf. We have the experience necessary to adapt these methods to a small scale for greenhouse or growth chamber plots. Other devices can replicate divots or holes. Since all root-zones in sports fields are man-made, these can be replicated in pots or boxes enabling many treatments within one growth chamber or greenhouse.



### Soil issues

High quality athletic fields are built with a root zone composed of about 90% sand and 10% peat. This provides a porous soil that is resistant to compaction. Underlying construction of gravel and drainage tiles further improves drainage of the rootzone. The profile of 6 to 12 inches of sand/peat over a 2 inch layer of fine gravel keeps the sand moist. A lower layer of coarse gravel and drain tile and allows excess water to move down and away in the drainage tiles. This construction is similar to USGA specification for golf greens. Some fields also incorporate pumps and fans into these sub-soil systems to push water into the profile from underneath and to introduce air into the rootzone.

### Plant growth regulators

Turfgrass growth and quality, especially in shady conditions, can be significantly improved with the use of plant growth regulators (PGRs). The most commonly used regulators block the production of gibberellic acid (GA) in the plants, which slows vertical growth and creates a darker green color. PGRs also increase carbohydrate production, which increases abrasion tolerance and wear resistance. PGRs are especially useful in shady conditions because plants grown under low light usually produce higher amounts of GA, which causes tall, spindly growth. Applications of anti-GA PGRs in shade-grown turf help reduce this elongation and results in a more robust plant.

### Supplemental management and construction techniques

SportGrass is a hybrid between artificial turf and natural grass. It is composed of a loosely woven nylon mat with long vertical fibers. The vertical fibers are top-dressed with sand to create a sand root zone interspersed with the nylon fibers. The fibers help create a tougher turf and increase the lateral stability. The SportGrass turf still "gives" like natural turf, but fewer large divots are removed during athletic events.

SquAyres and Netlon rootzone fibers are used together in a system. Netlon fibers are mixed with the rootzone mix to provide additional sod strength. The SquAyres system is designed to move large pieces of sod within the field or between nursery fields outside of the playing fields. This system allows replacement of damaged turf from the most frequently used parts of the field with turf from areas that experience very little traffic.

### FACILITIES AND PERSONNEL

The Utah State University Crop Physiology Laboratory is primarily supported by NASA and most research is directed towards optimizing growth of plant species and bio-regenerative life support systems. Much of this research includes hydroponics, elevated carbon dioxide and light levels and the development and testing of models and sophisticated new sensors for monitoring and control. This work has equipped the laboratory to carry out research projects on the production of crops in enclosed facilities, such as an athletic stadium.

**Bruce Bugbee** (Ph.D. Horticulture – Crop Physiology, Pennsylvania State University), Director of the Crop Physiology Laboratory, brings extensive expertise in effects of radiation (photons of light) quality, intensity and duration on photosynthesis and growth, nutrient management in recirculating hydroponic culture, sensors and methods for plant growth analysis, and plant/soil systems. He has served on several NASA and American Association of Biological Sciences peer review panels. Dr. Bugbee will lead the biological aspects of this research

effort.

**Paul Johnson** (Ph.D. Horticulture – Turfgrass Science, University of Minnesota), brings basic and applied expertise on the growth, culture, and genetics of turfgrasses. He is the Utah State Turfgrass Extension Specialist and has consulted on many athletic fields around the nation. Dr. Johnson also has served as Turfgrass Biotech Consultant to the Monsanto Corporation.