Gillette Stadium, Foxboro, MA

Managing field surface temperature

By Dr. Deying Li

Surface temperature has recently been raised as an important issue for artificial turf. With more and more artificial turf installed, sports turf managers are expected to manage an array of new things, including surface temperature.

This article discusses temperature as one of the important quality parameters of sport field surfaces. Results from a study comparing water use and temperature regimes between artificial turf and natural turfgrass indicated that managing soil temperature is more than a safety issue; turfgrass quality and environmental qualities can also be affected. Very small temperature differences can have big impact on biological reactions and accumulative temperatures.

Natural turfgrasses have many environmental benefits and functional attributes. With proper construction and maintenance, natural grass surfaces can tolerate reasonable use and provide a high quality playing surface for different games. Although the basic surface qualities for sports fields are stability, hardness, traction, and friction, other characteristics should never be overlooked including the ability to regulate temperature and humidity, and the ability of reducing dust and noise levels.

Sometimes artificial turf is preferred to accommodate larger amount of activities and prevent from fast deterioration. The advantages of artificial turf are at the cost of natural turf's environmental benefits. Some believe artificial turf requires no water or chemicals, but rather irrigation is needed for lowering the temperature and sanitation.

Temperatures building on artificial surfaces can become a concern during a warm day when surface temperature gets too high to play on safely. Under such situations, temperature is considered as one of the very important playing surface qualities. This is a good example that different parameters may dominate the surface playability under different circumstances.

Jack Trice Stadium, Iowa State University

Temperature has always been a very important factor of soil surface, too. Ironically, such is human nature that we tend to forget the most obvious and abundant, and we tend to take for granted the most essentials. The problem exposed due to the shift from natural turf to artificial turf is such an example; and thus, the debate of global temperature changes has spilled over to turfgrass management.

Thermal properties of rootzone media are very important physical factors that affect the energy balance and temperature distribution in rootzones used for sports turf applications. Understanding the patterns of soil temperature regime is helpful in making decisions as to when and how to apply water, fertilizers, and other chemicals. The information also is important in predicting infestations by weeds, diseases, and insect pests. The rational behind this is that plant growth, fate of chemicals, and microbial populations all are temperature dependent. Many turf management practices can affect the temperature and energy regime in the rootzones of turf. Some research has been conducted to investigate the effects of air and soil temperature on winter kill of turfgrasses. Topdressing turf with a heavy layer of sand, peat, bed coke, and other materials before winter for winter protection of turf has been successful in many cases. Physiological stress has been investigated on creeping bentgrass, Kentucky bluegrass, and other grasses under supraoptimal temperatures.

Direct heat stress has been reported when the internal crown tissue temperature was greater than 43°C. Until recently, little has been done to compare the temperature regimes of natural and artificial turf surfaces. Very little information is available on managing rootzone temperatures.

Temperature is a measurement of kinetic energy of molecules in a system. Heat flows along the temperature gradients, from higher temperature to lower temperature. The temperature of an object changes as a result of energy exchange. If it gives up more energy than it receives, it will be cooler; if it receives more energy than it gives up, it will be warmer. Three processes are responsible for heat transfer: conduction, convection, and radiation. Heat conduction is energy transfer from more energetic particles to less energetic particles of a substance due to interactions between the particles. Convection heat transfer is due to collective bulk motion of fluid. And radiation is energy emitted by matter at certain temperature.

Heat flow through soil involves the simultaneous operation of several different mechanisms mentioned above. Conduction is responsible for the flow of heat through the solid matrix, while across the pores conduction, convection, and radiation act in parallel. When soil is moist, latent heat of distillation adds an additional factor involved in heat transfer. This is why heat flow in soil system, therefore the temperature regime in a soil, is very complicated. Nevertheless, soil physicists developed different ways to study and describe soil energy transport and temperature changes.

Soil surface energy exchange causes the fluctuation of surface temperature. Temperature varies most on the surface and the changes damp off until at certain depth, where the temperature remains almost constant. Large temperature amplitude in the cyclical curve is a result of large amount of energy gain or loss. If the energy is not transferred downward (or upward for that matter) when thermal diffusivity is low, then the surface temperature tends to have large variations leading to bigger amplitude. The peaks and valleys of the temperatures in a lower layer will be at certain time behind that in an upper layer.

The lower the thermal diffusivity the longer is such time lag. The daily soil temperature changes, also called diurnal changes follow a similar pattern of annual cyclical temperature changes. We can use the amplitudes and time lags at different soil depths as indicators of soil thermal properties. Knowing that soil temperature regime is affected by thermal properties and that thermal properties are affected by soil types and water content, we can manage soil temperatures accordingly.

Experimental setup

The experiment was conducted in Fargo, ND. The plots were

Table 1. Daily surface maximum temperature and amplitude affected by turf type in the summer and fall of 2007.

Turf Type	Jun		July		Aug		Sept		Oct	
	Max	Amp	Max	Amp	Max	Amp	Max	Amp	Max	Amp
								°C		
KB	45.1	42.9	50.4	42.7	44.1	40.5	37.8	41.8	28.1	33.4
KB +FF	44.0	42.4	47.4	39.6	43.1	42.0	35.2	38.8	28.7	35.9
TF	40.9	37.2	41.1	30.0	38.6	37.1	39.0	42.0	28.4	35.0
FG Infill	54.8	50.6	52.2	43.0	50.0	44.8	46.4	46.5	34.5	39.4
Range	58.5	57.6	57.9	49.7	54.7	51.4	51.8	54.9	36.6	45.5

1.5 m by 2 m; rootzone is 30-cm mason sand on pea gravel with 10-cm diameter drain tiles connected to a lysimeter in each plot. Thermalcouple sensors at 0, 2.5, and 15 cm depths were installed in each plot. Soil moisture probes at 2.5 and 15 cm depth were installed in each plot. The treatment/materials are repeated three times in a randomized complete block design.

Three natural sports turf species mixtures were Kentucky bluegrass, Kentucky bluegrass/fine fescue, and rhizomatous tall fescue (Glenn Rehbein Turf). Forever Green with rubber crumb infill (ForeverGreen Athletic Fields) was one artificial sample, and Range turf (Synthetic Turf International) the other. All plots were sodded August 15, 2006.

Artificial turf clearly showed higher surface temperatures and longer durations of high temperatures compared with natural turf during the first growing season in 2007. Artificial turfs also showed larger fluctuation demonstrated by the higher amplitudes. As discussed above, the higher surface temperatures and larger amplitudes of artificial turfs were due to the lower thermal diffusivities of such materials. The time lags between the peak temperatures of surfaces and 15 cm depth in the rootzones also indicated that artificial turfs had slower energy exchanges between surface and sub surface than that of natural turfgrass. The results shown here are for the hottest month of July when grasses were established for only three months. As natural grasses grew more mature surface temperature extremes further decreased (data not shown).

During the experiment, the moisture levels of artificial turfs at 15-cm depth were either about the same or higher than that of the natural turfgrasses indicating that the lower thermal diffusivity at top 5-cm layer is more important for the heat dissipation. Since this layer of artificial turf tends to be more hydrophobic, more frequent watering maybe needed to maintain lower surface temperature because wetter soil has higher thermal diffusivity and larger heat capacity.

Soil properties as well as other environmental conditions can have great impact on surface temperatures. As little as

Courtesy of Lebanon Valley College

0.2 °C differences are biologically significant. The significance is reflected both in temperature thresholds for certain biochemical reactions and for degree-day accumulations. It is a good practice to monitor soil temperatures closely and use the information for irrigation as well as pest control.

To prevent overheating at the surfaces of artificial turfs, either frequent watering or using soil amendments to make the surface less hydrophobic maybe necessary.

In addition to irrigation, selection of soil textures (relative amount of sand, silt, clay, and organic matter) and managing soil structures and thatch levels (aeration, fertilization, topdressing, and mowing) are also useful tools to regulate soil temperatures.

Thermal properties can be tested by a soil physical laboratory for different soil types at different moisture levels. Such test is also useful if soil heating and cooling system is to be installed in the sport fields. ■

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