Penn State's

Center for
Sports Surface Research

Ready Play Field Magic Testing

January 2012

Executive Summary

Outdoor Study
An evaluation of Ready Play Field Magic was conducted at Penn State's Joseph E. Valentine Turfgrass Research Center located in University Park, PA. Field Magic was incorporated into a soil mix that is commonly used for the skinned area of a baseball infield and its effect on various soil properties was evaluated. Field Magic affected volumetric soil moisture content by up to 2% at certain rating times, but when measured on a weight basis, no differences in soil moisture were found. Field Magic also showed a tendency to reduce surface hardness (Gmax).

Indoor Study
Laboratory testing was conducted to determine the amount of moisture lost over time under simulated sunny conditions. Field Magic was incorporated into a soil mix that is commonly used for the skinned area of a baseball infield and compared to a sample that did not contain Field Magic. The mix that included Field Magic exhibited a general trend of 0.5 to 2% higher moisture content than the control over 10 hours.

Outdoor Study

Objective
The objective of this project was to evaluate the effects of various rates of Field Magic mixed into a baseball infield on soil moisture content, surface hardness, soil bulk density, and soil surface color.

Testing Procedure
Plot Installation
The research plot area contained Diamond Tex Premium infield mix installed to a depth of four inches (installed in 2005). This mix consisted of 10% gravel, 56% sand, 27% silt, and 7% clay. Treatments included mixing various rates of Field Magic into the top two inches of the Diamond Tex mix using a rototiller (July 28, 2011). Plots were then compacted using the tires of a utility cart, raked, and received 0.8 inches of precipitation (0.2 inches from irrigation system, 0.6 inches rainfall). Each plot was 5 ft. x 10 ft. Three replications of the following treatments were included:

- 0 lbs of Field Magic (control)
- 80 lbs of Field Magic per 1000 ft^2
- 120 lbs of Field Magic per 1000 ft^2
- 160 lbs of Field Magic per 1000 ft^2

Figure 1. Field Magic application onto research plots

Figure 2. Field Magic on the surface prior to tilling

Figure 3. 80 lb /1000 ft^2 rate (left) and 160 lb /1000 ft^2 rate (right)

Figure 4. Plots were tilled one time using a rototiller

Figure 5. Tilling depth was 2 inches

Figure 6. Plots were raked following compaction

Figure 7. After installation, plots received 0.8 inches of water (combination of irrigation and rainfall)

The following morning (July 29), the plots were raked again and irrigated with 0.1 inches of water. The plot area received no water on July 30. The plots were then irrigated again on July 31 with 0.2 inches of water. On the following day, the plots were nail-dragged and dragged with a metal drag mat. The plots then received an additional 0.2 inches of water (irrigation and rainfall). Between irrigation and rainfall, the plots received a total of 1.3 inches of water from the time immediately after installation until the day of data collection.

On the morning of data collection (Aug 2), plots were nail-dragged, dragged with a metal drag mat, and lightly hand-watered. Hourly data collection began at 9:00 AM and ended at 4:00 PM (eight consecutive hours of data collection).

Figure 8. Plots were nail-dragged the morning of data collection

Figure 9. After nail-dragging, a metal drag mat was used on the plots

Figure 10. A view of the plots after dragging and before hand-watering

Figure 11. Plots were lightly hand-watered 15 minutes before the first data collection time

The following data was collected hourly from 9:00 AM to 4:00 PM.

- Volumetric Soil Moisture Content (soil moisture on a volume basis)
    - Measured with the Troxler 3400-B Series moisture density gauge (Troxler Electronic Laboratories, Research Triangle, NC) using backscatter mode. The Troxler gauge uses neutron scattering to measure the volumetric soil moisture content (Gardner, 1986).

Figure 12. Troxler 3400-B Series moisture density gauge

- Gravimetric Soil Moisture Content (soil moisture on a weight basis)
    - Measured by removing a sample from the top ½" of each plot and subsequently weighing it (weight of soil and water) and then drying it and weighing it again (weight of soil). Percent soil moisture content was determined by dividing the weight of the water by the weight of the soil and water.

Figure 13. A sample was taken from the top 1/2 inch of each plot to determine gravimetric water content

- Soil Bulk Density
    - Measured with the Troxler 3400-B Series moisture density gauge (Troxler Electronic Laboratories, Research Triangle, NC). The Troxler gauge uses gamma ray attenuation to determine total density (Gardner, 1986). Soil bulk density is then derived by subtracting density due to water from total density.

- Surface Hardness (Gmax)
    - Measured with the Clegg Impact Tester (Lafayette Instrument Company, Lafayette, IN). The Clegg Impact Tester contains a 5 lb missile that is dropped from a height of 18 inches (ASTM, 2010). The missile contains an accelerometer that measures deceleration upon impact. The maximum deceleration is referred to as Gmax. The average of three drops (at different locations within the plot) was used to represent Gmax during each data collection.

Figure 14. The Clegg Impact Tester was used to evaluate surface hardness

- Surface Color
    - Measured by Model CR-310 chromameter (Minolta Co, Ltd, Ramsey, NJ). Output included lightness (0 = black, 100 = white), chroma (degree of gray on 0

to 60 scale), and hue angle (hue angles of the four primary colors are: red, 0°; yellow, 90°; green, 180°; and blue, 270°). The average of three ratings (at different locations within the plot) was used to represent lightness, chroma, and hue during each data collection.

Figure 15. Chromameter used to measure surface color

In addition to the hourly data collected on Aug 2, additional data was collected on Aug 11 and 12 at 2:00 PM each day. The collection dates were selected to represent an overall drier condition as no irrigation/rainfall had occurred during the preceding 48 hours.

The weather conditions at each data collection time are shown below.

Table 1. Weather conditions at the time of each data collection.

Time	Temperature (F)	Humidity	Wind speed	Cloud cover
9:00 AM	77°	52 %	0 MPH	0 %
10:00 AM	80°	49 %	0 MPH	20 %
11:00 AM	81°	38 %	8 MPH	20 %
12:00 PM	82°	39 %	6 MPH	20 %
1:00 PM	84°	35 %	8 MPH	10 %
2:00 PM	88°	31 %	13 MPH	10 %
3:00 PM	88°	29 %	12 MPH	10 %
4:00 PM	88°	29 %	10 MPH	20 %
2:00 PM (Aug 11)	73°	40 %	12 MPH	40 %
2:00 PM (Aug 12)	75°	47 %	5 MPH	20 %

Statistical Analysis

The experimental design was a randomized complete block design. Means for each category of data were analyzed using analysis of variance and comparisons were made using Tukey's Honest Significance Test at the 0.05 level. A Tukey's Honest Significance Test was not performed when the F statistic resulted in a p value of >0.05. Data from each collection time was analyzed independently. Additionally, data for each measurement was combined into 4-hour groupings

(9:00 AM to 12:00 PM and 1:00 PM to 4:00 PM) and one 8-hour grouping and tested using the procedure described above.

Results

Volumetric Soil Moisture Content

During the 8-hour collection day, there were statistical differences among treatments at three data collection times (11:00 AM, 1:00 PM, and 3:00 PM; see Table 2). Differences at these times were less than 2%. The 160 lb rate generally resulted in a higher soil moisture percentage than the control at these ratings times. Volumetric soil moisture content data among treatments at all other collection times (including Aug 11 and 12) were not statistically different (i.e. the moisture contents for each treatment were not different from one another), but trended higher with the addition of Field Magic

When grouping the 8 hours of data into two groups (first 4 hours, second 4 hours), there was no statistical difference among treatments during the first 4-hour block (9:00 AM to 12:00 PM), but there was a statistical difference during the second 4-hour block (1:00 PM to 4:00 PM). This was a difference of 1% (Table 2). The practical significance of this difference will have to be determined by end users. Additionally, there was no statistical difference among the treatments when all eight hours of data were grouped together.

Table 2. Volumetric soil moisture content percentages at the data collections times when statistical testing showed significant differences.

Treatment	11:00 AM	1:00 PM	3:00 PM	1 to 4 PM
	----------Vol. Soil Moisture Content (%)----------			
Control	11.2 b*	10.8 b	10.1 b	10.3 b
80 lbs Field Magic	11.9 ab	11.1 ab	10.4 b	10.8 ab
120 lbs Field Magic	12.9 a	11.4 ab	10.8 ab	10.9 ab
160 lbs Field Magic	12.6 ab	11.9 a	11.7 a	11.3 a

*Means with the same letter are not significantly different from one another. Comparisons only apply within one data time and do not apply across times.

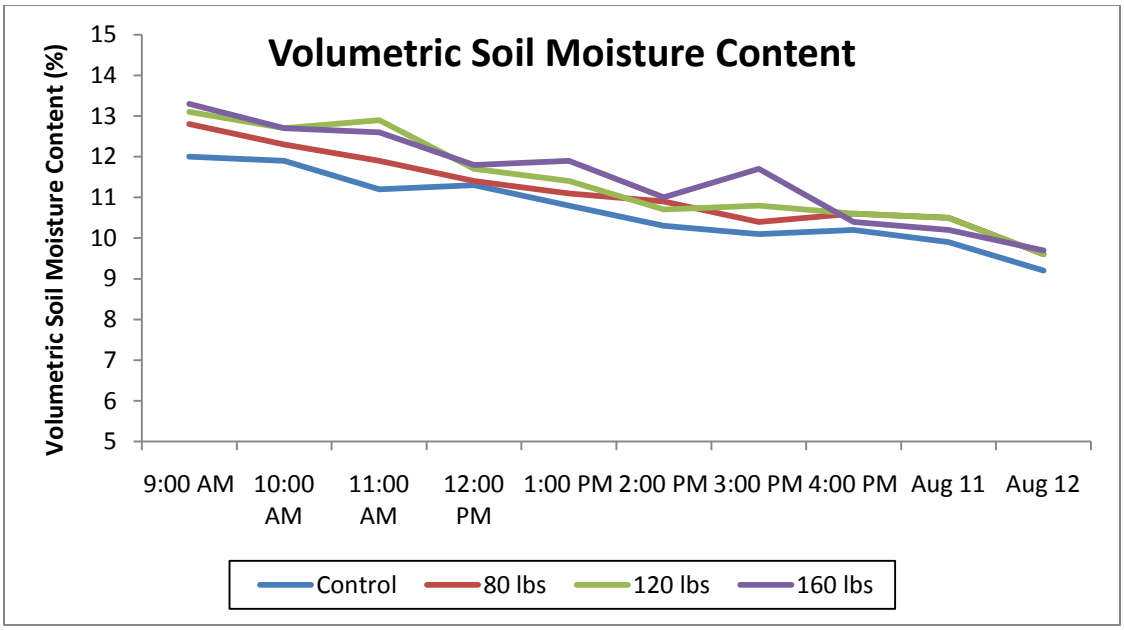

Figure 16. Volumetric soil moisture content percentages for each treatment over time. Note: Aug 11 and Aug 12 data was collected 9 and 10 days respectively after the original data collection date

Gravimetric Soil Moisture Content

There were no statistical differences among treatments at any rating time or when combining data collection times into 4-hour groupings or an 8-hour grouping. Means are shown below in Figure 17.

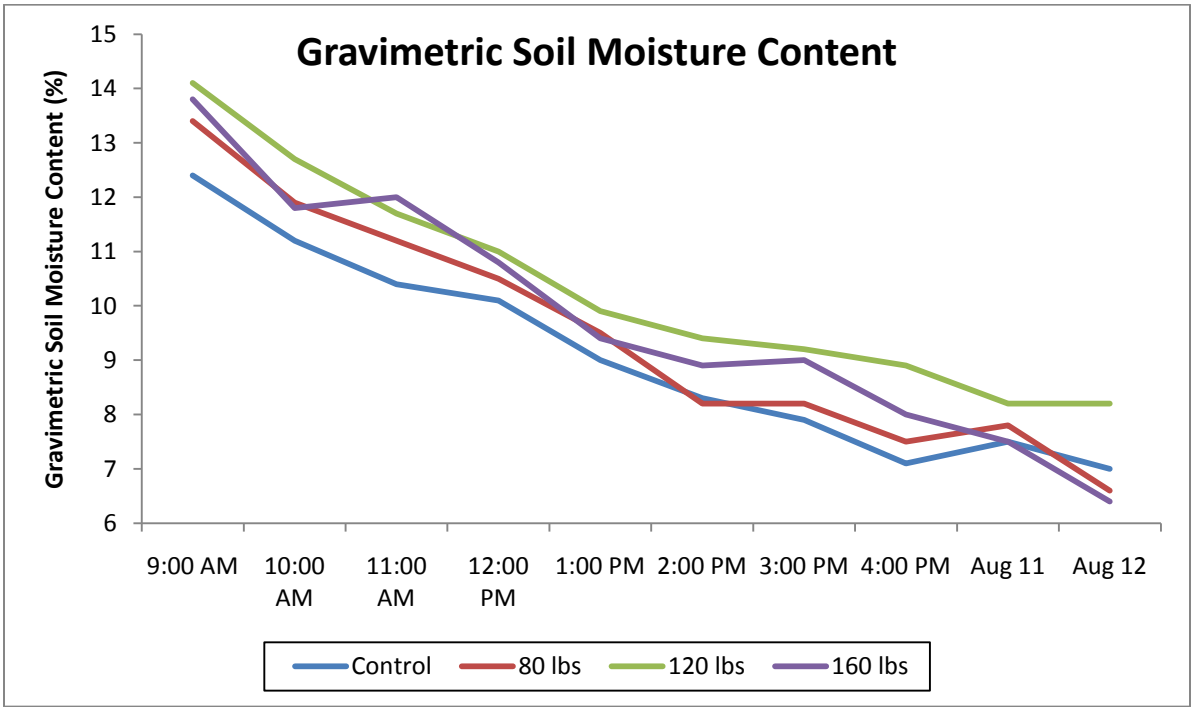

Figure 17. Gravimetric soil moisture content percentages for each treatment over time. There were no statistical differences. Note: Aug 11 and Aug 12 data was collected 9 and 10 days respectively after the original data collection date

Soil Bulk Density

During the 8-hour data collection day, there were statistical differences among treatments at one data collection time (11:00 AM; see Table 3). While statistically significant results were not found at the other rating times, a trend of higher soil bulk density on control plots, especially when compared to the 160 lb rate, was observed throughout the 8 hour day (see Fig. 18).

When combining soil bulk density data from 1:00 to 4:00 PM, statistical analysis showed that the bulk density in the plots containing the 160 lb rate of Field Magic was lower than the control plots. Combining all eight hours of data collection showed a similar trend (although not statistically significant; p = 0.056).

Table 3. Soil bulk densities at the data collections times when statistical testing showed significant differences.

Treatment	11:00 AM	1 to 4 PM
	----------g / cm^3----------	
Control	1.88 a*	1.87 a
80 lbs Field Magic	1.83 ab	1.82 ab
120 lbs Field Magic	1.74 b	1.81 ab
160 lbs Field Magic	1.72 b	1.77 b

*Means with the same letter are not significantly different from one another. Comparisons only apply within one data time and do not apply across times.

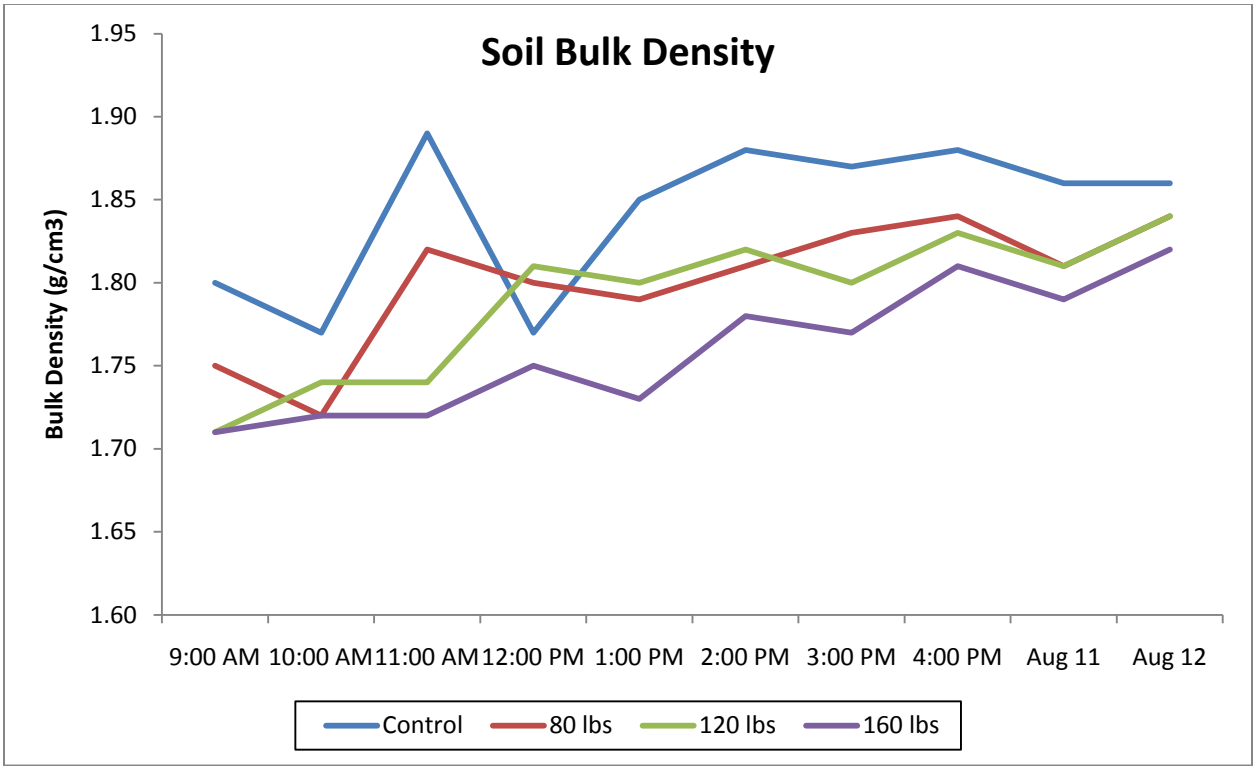

Figure 18. Soil bulk density values for each treatment over time. Note: Aug 11 and Aug 12 data was collected 9 and 10 days respectively after the original data collection date (Aug 2)

Surface Hardness (Gmax)

During the 8-hour data collection day, there were statistical differences among treatments at two data collection times (1:00 PM, and 2:00 PM; see Table 4). While statistically significant results were not found at the majority of rating times, a trend of higher Gmax on control plots was observed throughout the 8 hour day (see Fig. 19).

Although there were few statistical differences when analyzing the hourly data, when data was combined into groups, statistical differences were found. For example, when combining all eight hours of data from the Aug 2 rating date, Gmax on both the 120 lb (Gmax = 64) and 160 lb (Gmax = 61) rate plots was lower than on control (Gmax = 83) plots (see Table 3). Similar differences were found when grouping data from 1:00 PM to 4:00 PM. (There were no statistical differences when grouping data from 9:00 AM to 12:00 PM).

Table 4. Surface hardness values at the data collections times when statistical testing showed significant differences.

Treatment	1:00 PM	2:00 PM	1 to 4 PM	9 AM to 4 PM
	----------Surface Hardness (Gmax)----------			
Control	94 b*	89 b	88 b	83 b
80 lbs Field Magic	60 a	73 ab	70 a	65 ab
120 lbs Field Magic	68 a	70 a	68 a	64 a
160 lbs Field Magic	64 a	66 a	66 a	61 a

*Means with the same letter are not significantly different from one another. Comparisons only apply within one data time and do not apply across times.

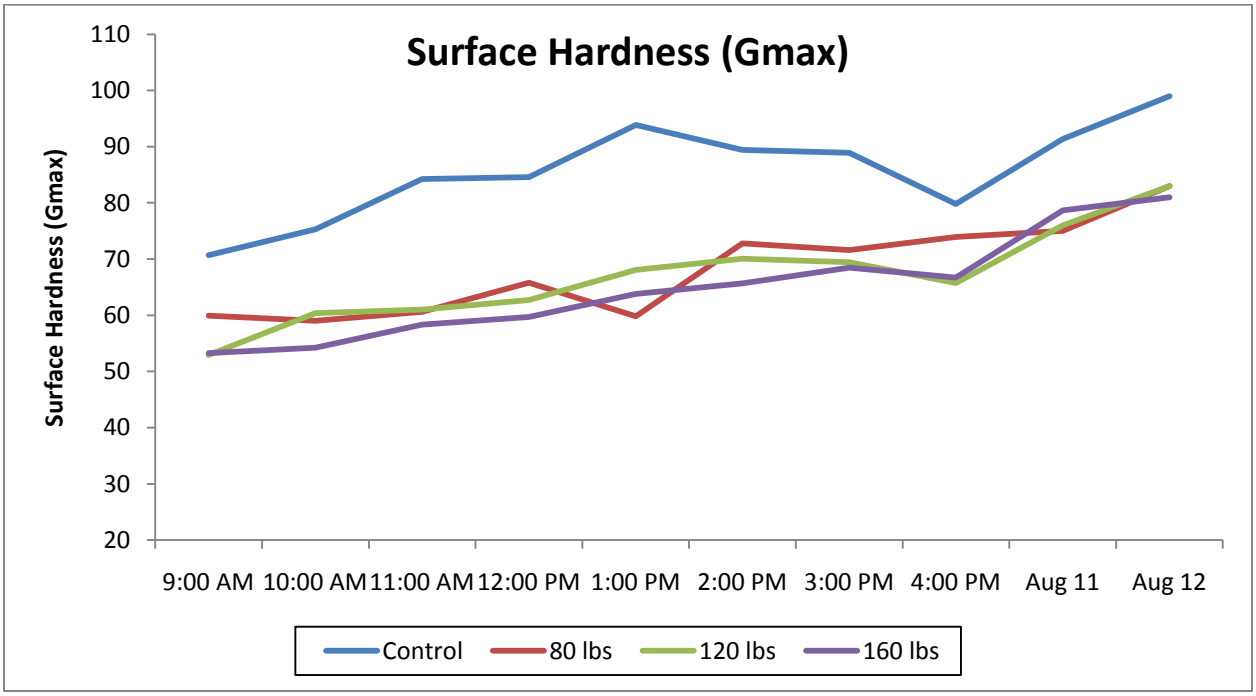

Figure 19. Surface hardness values for each treatment over time. Note: Aug 11 and Aug 12 data was collected 9 and 10 days respectively after the original data collection date (Aug 2)

Surface Color

There were no statistical differences in surface color at any rating time or when combining ratings times for lightness, chroma, or hue angle. In addition to the chromameter data, there was no discernible visual difference when informally comparing plot color by eye (see Fig. 20).

Figure 20. View of the plots at the 4:00 PM rating time

Summary of Outdoor Study

Field Magic affected volumetric soil moisture content compared to control plots by nearly 2% at certain rating times under the conditions of this study. When soil moisture was measured on a weight basis, no differences in soil moisture were detected. The 160 lbs per 1000 ft^2 rate of Field Magic showed some evidence of reducing soil bulk density compared to the control and the mean bulk density data indicates a trend for the other rates to also reduce bulk density, although differences were not statistically significant. There was evidence that Field Magic reduced surface hardness compared to the control. For example, the addition of Field Magic lowered Gmax by approximately 20 g's compared to control plots when analyzed over 8 hours of data collection. This was most likely the result of lower soil bulk density. A reduction in surface hardness may be an important effect of the addition of Field Magic as the Gmax of some professional baseball field skinned base paths have been found to be very high (Brosnan and McNitt, 2008).

Laboratory Study

Objective

The objective of the laboratory study was to evaluate the effects of Field Magic mixed into a baseball infield mix on soil moisture content.

Testing Procedure

A laboratory test was conducted to evaluate the effect of Field Magic on soil moisture content of a common infield mix. Field Magic was combined with infield mix (10% gravel, 56% sand, 27% silt, and 7% clay) at a rate of 120 lbs / 1000 ft^2. The Field Magic sample and the control were each installed into a four-inch diameter PVC pipe with a height of two inches. For each test, the samples were packed to a bulk density of 1.78 g/cm^3. In the first test, the samples were placed into a water bath for 24 hours to allow for saturation. During the saturation process, the samples increased in volume (swelled), with the Field Magic sample increasing to a greater extent than the control (see Fig 21). The volume of soil above the top of the pipe was removed prior to testing and subsequently dried and subtracted out of total soil mass prior to moisture content calculations. This allowed for determination of volumetric moisture content and moisture content on a weight basis. In the second test, the samples were prepared in the same manner as in the first test but remained in the water bath for a longer period of time prior to testing (6 days). Unlike the initial test, the soil that swelled above the top of the pipe after saturation was not removed prior to testing. As a result, only moisture content on a weight basis was determined.

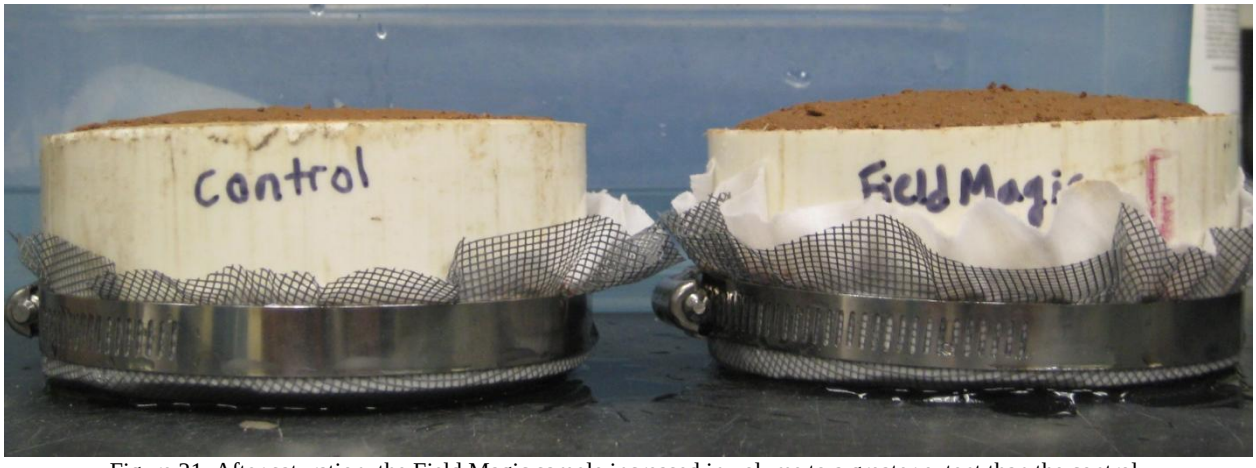

Figure 21. After saturation, the Field Magic sample increased in volume to a greater extent than the control

The saturated samples were then placed onto a scale under a 250-watt infrared heat lamp to simulate sunny conditions (Fig. 22). Changes in the mass of the samples were recorded on an hourly basis for 10 hours and a final mass was recorded after 24 hours. The change in mass represented the amount of water evaporating from the sample. These tests were not replicated.

Figure 221. Each sample was placed onto a scale under a heat lamp

Results

Test 1

Table 5. Volumetric moisture content and moisture content on a weight basis values over the first 10 hours under the heat lamp and after 24 hours. Values in parentheses indicate the difference in moisture content between Field Magic and the control.

	Volumetric Moisture Content		**Moisture Content – Weight Basis**	
	Control	Field Magic	Control	Field Magic
Time	----------%----------		----------%----------	
0 hrs	33.5	34.3 (+0.8)	19.8	21.1 (+1.3)
1 hrs	31.3	33.1 (+1.8)	18.5	20.3 (+1.8)
2 hrs	29.8	31.0 (+1.2)	17.6	19.1 (+1.5)
3 hrs	27.5	28.8 (+1.3)	16.3	17.7 (+1.4)
4 hrs	25.6	27.0 (+1.4)	15.1	16.6 (+1.5)
5 hrs	23.5	25.1 (+1.4)	13.9	15.4 (+1.5)
6 hrs	21.7	23.3 (+1.6)	12.8	14.3 (+1.5)
7 hrs	19.8	21.5 (+1.7)	11.7	13.2 (+1.5)
8 hrs	17.9	19.8 (+1.9)	10.6	12.2 (+1.6)
9 hrs	16.3	18.2 (+1.9)	9.6	11.2 (+1.6)
10 hrs	14.7	16.8 (+2.1)	8.7	10.3 (+1.6)
24 hrs	5.1	7.1 (+2.0)	3.0	4.3 (+1.3)

Test 2

Table 6. Moisture content values (weight basis) over the first 10 hours under the heat lamp and after 24 hours. Values in parentheses indicate the difference in moisture content between Field Magic and the control.

	Moisture Content – Weight Basis	
	Control	Field Magic
Time	----------%----------	
0 hrs	24.2	24.8 (+0.6)
1 hrs	23.4	24.1 (+0.7)
2 hrs	22.2	22.9 (+0.7)
3 hrs	21.0	21.6 (+0.6)
4 hrs	19.7	20.4 (+0.6)
5 hrs	18.6	19.2 (+0.6)
6 hrs	17.5	18.2 (+0.7)
7 hrs	16.5	17.2 (+0.7)
8 hrs	15.5	16.3 (+0.8)
9 hrs	14.4	15.3 (+0.9)
10 hrs	13.4	14.5 (+1.1)
24 hrs	6.9	6.7 (-0.2)

Summary of Laboratory Study

The inclusion of Field Magic (120 lb / 1000 ft^2) resulted in a general trend of increasing soil moisture content by 0.5 to 2%.

References

ASTM Standard F1702, 2010. Standard Test Method for Measuring Impact Attenuation Characteristics of Natural Playing Surface Systems Using a Lightweight Portable Apparatus. ASTM International, West Conshohocken, PA DOI:10.1520/F1702-10, www.astm.org.

Brosnan, J. T., and A.S. McNitt. 2008. Surface conditions of highly maintained baseball fields in the northeastern United States: Part 1, non-turfed basepaths. Online. Applied Turfgrass Science doi:10.1094/ATS-2008-0520-01-RS.

Gardner, W.H. 1986. Water content. P. 493-544. *In* A. Klute (ed.) Methods of Soil Analysis. Part 1-Physical and Mineralogical Methods-Agronomy Monograph #9 (2^{nd} edition). American Society of Agronomy, Madison, WI.