Field & Greenhouse Turfgrass Evaluation of Fertiactyl Liquid Fertilizer (GZ-GTO) and PhysioCal Soil Conditioner Treatments

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Submitted by: Max Schlossberg, Ph.D., Assoc. Prof. Turfgrass Nutrition; Derek T. Pruyne, Graduate Research Asst.; and Kyle R. Hivner, Research Assoc.; Center for Turfgrass Science.

Turfgrass managers have keen interest in reports of product efficacy trials that describe quantifiable and resolute measures of turfgrass health, canopy density, and color. Likewise, direct measurement of turfgrass growth rate (clipping yield) provides nutrient-availability induced estimates of turfgrass vigor.

Objective To comprehensively evaluate the influence of Fertiactyl liquid fertilizer (GZ-GTO; 13-0-5) and/or PhysioCal (3-0-0, 23% Ca) soil conditioner on soil chemical optimization and canopy density, color, and wear recovery of a managed Kentucky bluegrass system in the field; as well as establishment vigor and root system development of turf-type tall fescue under greenhouse conditions.

Turf-Type Tall Fescue (TTTF) Greenhouse Establishment Study: Materials & Methods
On 12 June, 2013, thirty 'cone-tainer' pots (2.5" i.d. X 9" deep) were packed with a homogenized sandy loam and fertilized to support tall fescue establishment; specifically 0.7 lbs N, 1.4 lbs P_2O_5, 1.4 lbs K_2O, 0.14 lbs S, and 0.1 lbs Mg / M rates using reagent-grade monoammonium phosphate (MAP; 11-52-0), KNO_3 (13-0-44), and Epsom salts. Before seeding with a 1:1 blend of 'Cochise IV' and '3rd Millennium' turf-type tall fescue cultivars (7 lbs pure live seed / M), half of the cone-tainers had PhysioCal (3-0-0, 23% Ca) incorporated into the upper 2" at a rate of 10 lbs / M on 13 June, 2013.

Treatment (TTTF Study)	Fertiactyl	PhysioCal
(1) Control	0 oz. / M	0 lbs / M
(2) GZ-GTO Low	0.75 + 0.75 oz. / M	0 lbs / M
(3) GZ-GTO Low + PhysioCal	0.75 + 0.75 oz. / M	10 lbs / M
(4) GZ-GTO High	5.0 oz. / M	0 lbs / M
(5) GZ-GTO High + PhysioCal	5.0 oz. / M	10 lbs / M
(6) PhysioCal ONLY	0 oz. / M	10 lbs / M

Fig. 1. Cone-tainers and turf-type tall fescue (TTTF) seedlings; 2 July 2013.

Cone-tainers were lightly-irrigated each day until seedling emergence (June 30), and mowed at a 1.5" height weekly thereafter (Figure 1). On 11 July, 2013, the 24 most uniformly-established cone-tainers (12 having received the PhysioCal treatment) were selected and randomly-arranged in 4 replicate blocks. The next day, cone-tainers designated for liquid Fertiactyl (GZ-GTO; 13-0-5) applications were treated in 50 gallons /acre carrier volume as shown (Table above). On 26 July, 43 days after initial treatment (DAIT) by PhysioCal, and 14 days after initial Fertiactyl (GZ-GTO) treatment, cone-tainers originally treated at the low GZ-GTO rate (0.75 oz. / M) were retreated as described (for a total rate of 1.5 oz. GZ-GTO / M).

Greenhouse temperature was maintained within a range of 60 to 88 ^{o}F, and no supplemental lighting was employed. The cone-tainers were scouted/treated for pest activity and irrigated as necessary over the 60-day experimental period. Clipping yields were collected 43 and 54 days after seeding (14 and 25 days after initial Fertiactyl GZ-GTO treatments). Dry yield masses were determined for each cone-tainer to quantify establishment vigor. Sixty-days following seeding (12 August), soil in the 1-6" depth of all cone-tainers were washed from roots (Figure 2), dyed for 48-hours in neutral red, and transmissively scanned in a water bath at 800-dpi resolution (Figure 3). Resulting images were analyzed for root length density (cm / cm^3), mean root surface area (cm^2), and mean root diameter (mm) using WinRhizo™ Root Quantification Software (Ver. 2005, Regent Industries Inc.).

Fig. 2. Harvesting turf-type tall fescue (TTTF) root systems from cone-tainers; 12 August 2013 (60 days after seeding).

Turf-Type Tall Fescue (TTTF) Greenhouse Establishment Study: Results

Clipping yields were collected 43 and 54 days after initial treatment (DAIT). Yields collected 54 DAIT were significantly greater than yields collected 43 DAIT (data not shown), and a likely result of reapplication of the Fertiactyl GZ-GTO low rates to two of the six treatment levels immediately following the 43 DAIT clipping collection. Only mean clipping yields (averaged over both dates) are shown (Figure 4a). Mean clipping yields from the cone-tainers receiving the low GZ-GTO rate with and without PhysioCal, and the cone-tainers receiving the high

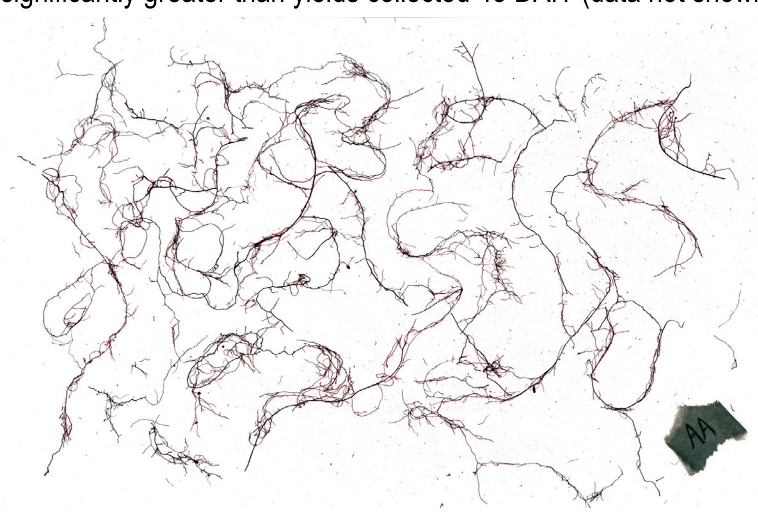
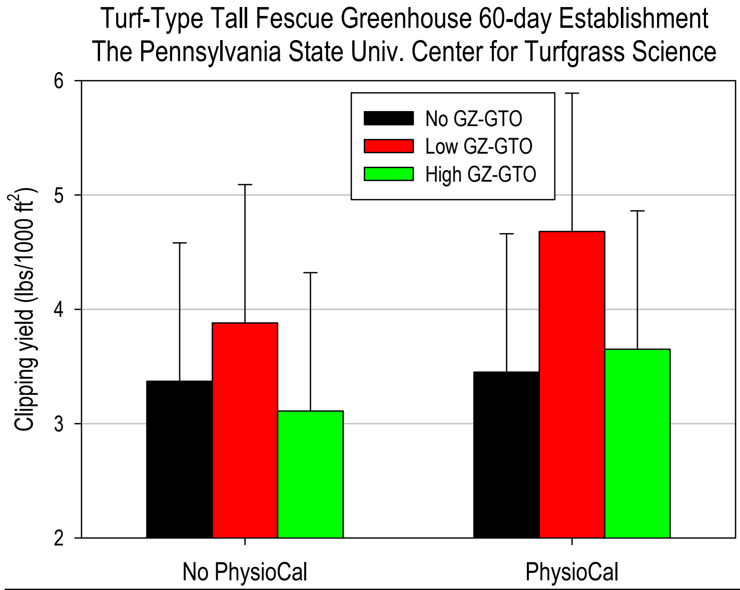
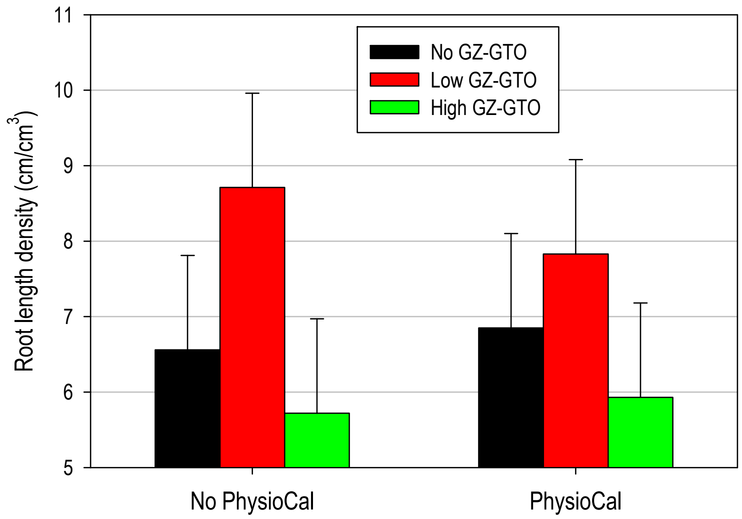


Fig. 3. Image scan of washed and dyed turf-type tall fescue roots used in WinRhizo™ root analysis.



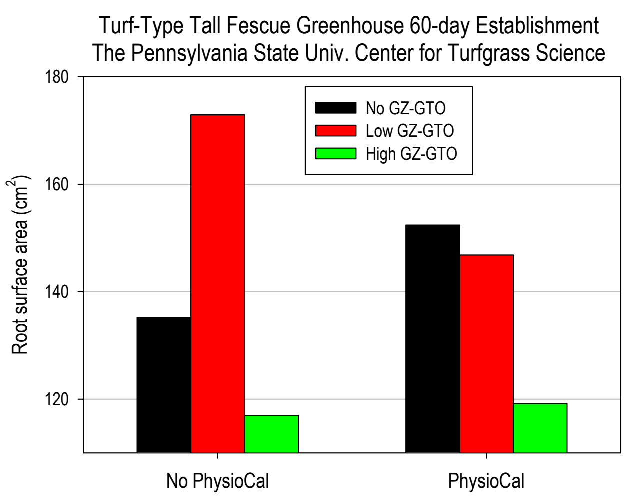
Figs. 4a-b. Mean clipping yield (a, above) and root length density (b, below) of turf-type tall fescue (TTTF) seedlings. Means having overlapping error bars are not significantly different (alpha = 0.05).

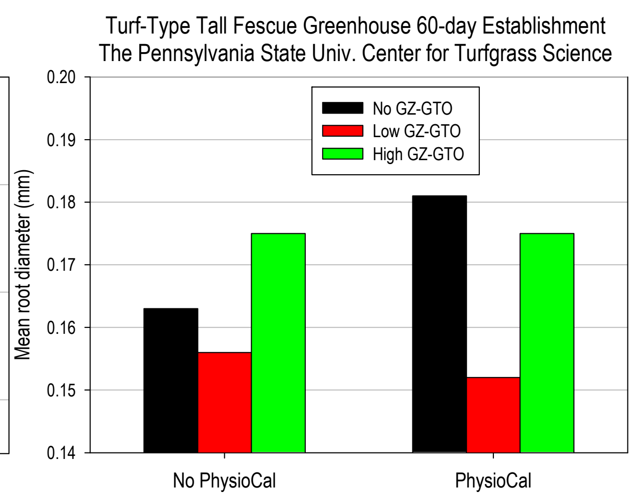


GZ-GTO rate with PhysioCal; comprise the highest statistical grouping. The PhysioCal treatment in combination with the low rate of Fertiactyl GZ-GTO resulted in a significant increase (39%) in clipping yield/shoot growth compared to the control (Figure 4a).

Root length density in the 1-6” soil depth, determined 60 days after seeding, was significantly affected by treatment. Root length densities measured in cone-tainers receiving the low GZ-GTO rate with and without PhysioCal comprise the highest statistical grouping (Figure 4b). The PhysioCal treatment in combination with the low rate of Fertiactyl GZ-GTO resulted in significantly greater (19%) root length density relative to the control. The low rate of Fertiactyl GZ-GTO alone resulted in significantly greater (33%) root length density compared to the control (Figure 4b). Treatments did not significantly influence mean root surface area (cm^2) or mean root diameter (mm) over the 60 day experimental period (Figure 5).

Figs. 5bl-br. Mean root surface area (bl, below left) and diameter (br, below right) of turf-type tall fescue (TTTF) seedlings 60 DAIT. No significant differences between treatments were observed.





Kentucky Bluegrass Athletic Field Study 1: Materials & Methods
In May 2013, twenty-four plots (each 12 ft^2), were sited on an intensively-maintained Kentucky bluegrass athletic field system in a randomized complete block design. Traffic/wear treatments were applied by six passes of a Brinkman Traffic Simulator (Vanini et al., 2007) on both May 30 and June 2 (Figure 6).

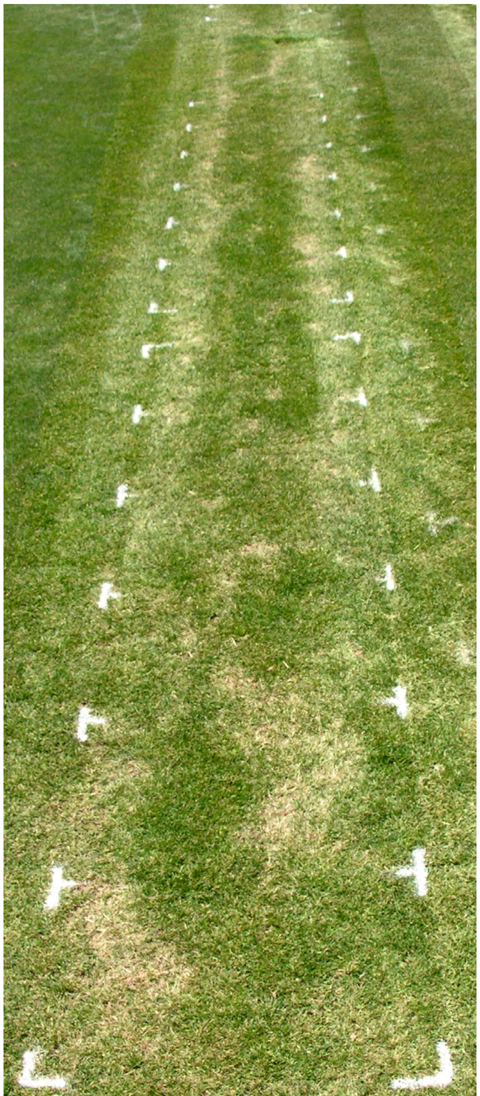


Fig. 6. Appearance of plots following wear/traffic treatments; 2 June 2013.

Granular PhysioCal (3-0-0, 23% Ca) and/or liquid Fertiactyl GT-GZO (13-0-5) applications were applied to randomly-selected plots (in each of four replicate blocks) on June 3 in the treatment-rate combinations shown (Table below). Fertiactyl (GZ-GTO) treatments were made in 50 gallons /acre carrier volume, and all treatments lightly watered in following application. Plots were mowed at a 1" height three times each week, scouted/treated for pests, and irrigated as necessary over the 30-day experimental period.

Treatment (KBAF Study 1)	Fertiactyl	PhysioCal
(1) Control	0 oz. / M	0 lbs / M
(2) GZ-GTO Low	0.75 oz. / M	0 lbs / M
(3) GZ-GTO Low + PhysioCal	0.75 oz. / M	10 lbs / M
(4) GZ-GTO High	5.0 oz. / M	0 lbs / M
(5) GZ-GTO High + PhysioCal	5.0 oz. / M	10 lbs / M
(6) PhysioCal ONLY	0 oz. / M	10 lbs / M

Beginning one day after initial treatment (1 DAIT), simultaneous measures of 660– and 850–nm reflectance from the canopy of each plot were recorded in triplicate using an ambient light-excluding FieldScout TCM–500 turfgrass chlorophyll meter (Spectrum Technologies Inc., Plainfield, IL). These weekly reflectance data were used to calculate normalized differential vegetative indices (NDVI). On an identical frequency, a color meter (FieldScout TCM-500-RGB) collected triplicate measures of green, red, and blue canopy reflectance. These data were converted to hue, saturation, and brightness levels to determine dark green color index (DGCI; Karcher & Richardson, 2003). These NDVI and DGCI indices provide dependably-reproducible measures of turfgrass canopy density and dark green color, respectively (Zhu et al., 2012).

Kentucky Bluegrass Athletic Field Study 1: Results
Field conditions in May and June 2013 were atypically cool and moist, relative to recent seasons in central Pennsylvania (Figure 7). No desiccation injury was observed to result from the described Fertiactyl GZ-GTO and/or PhysioCal treatment applications.

Reflectance indices of the Kentucky bluegrass athletic field, pooled over Study 1, were low and indicative of recent injury (Figure 8). Mean canopy density (NDVI) of the Kentucky bluegrass athletic field, pooled over the five weekly readings taken in Study 1, did not indicate a statistical effect of treatment (Figure 8bl). However, similarly pooled mean canopy dark green color indices (DGCI) were significantly influenced by

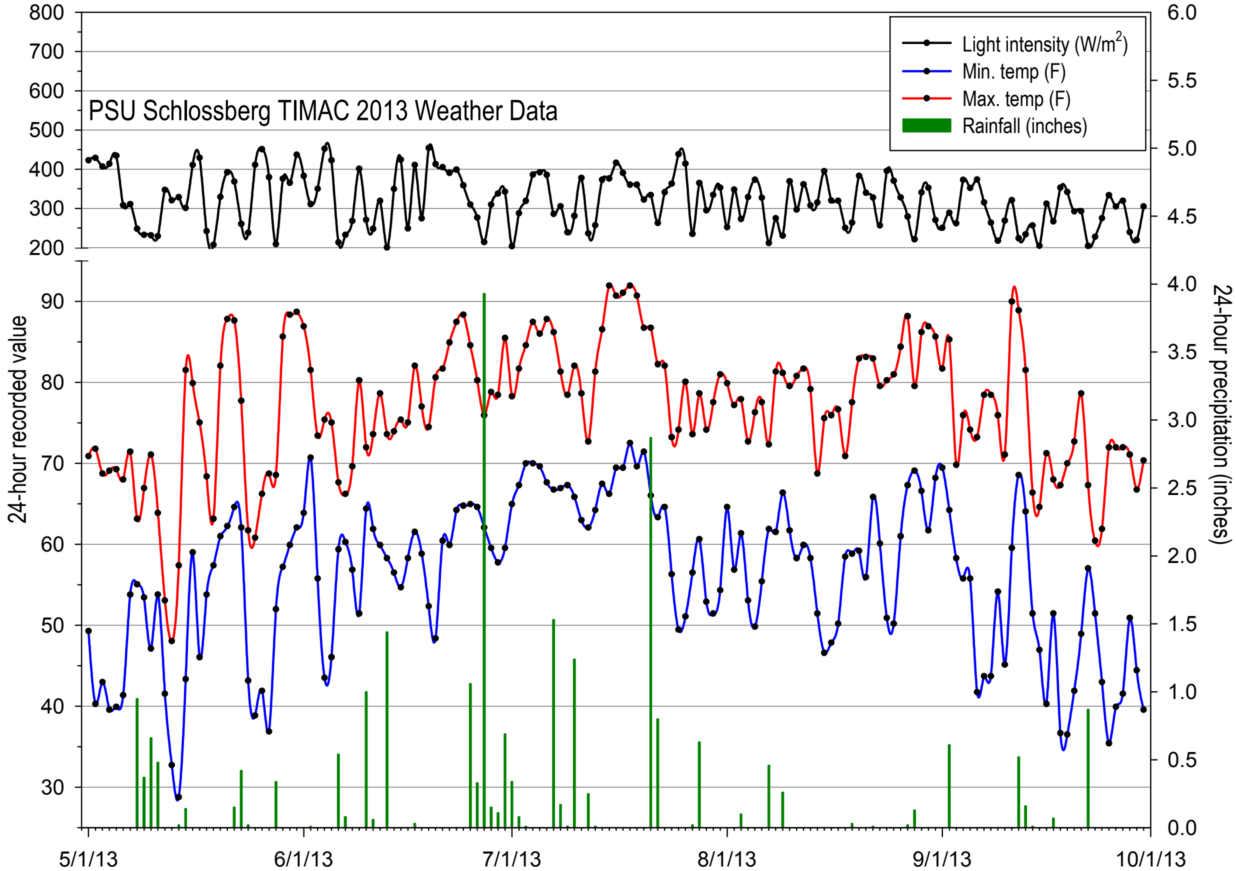
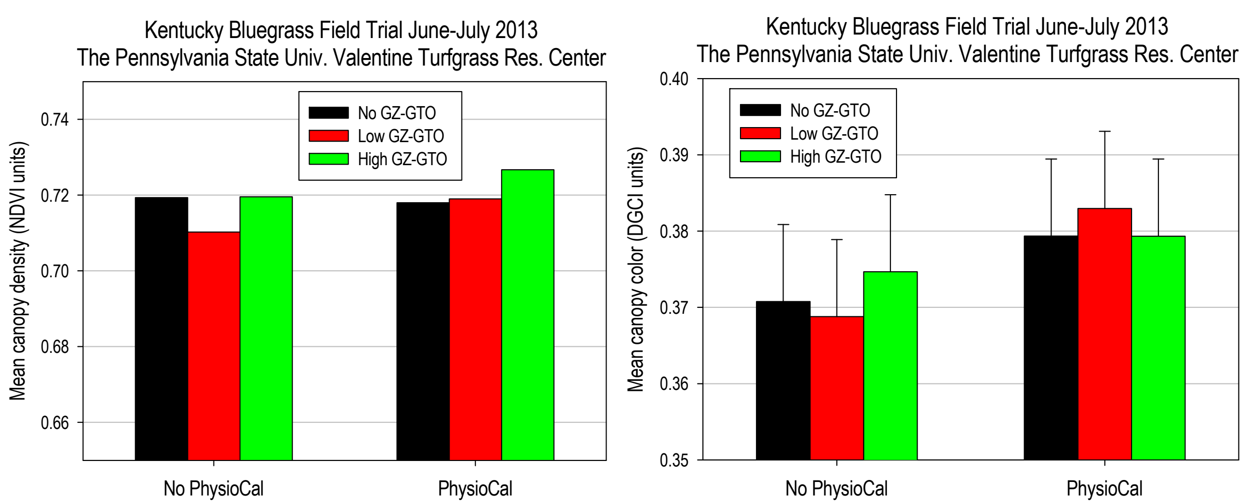


Fig. 7. Weather conditions recorded at the PSU Valentine Turf Res. Center, May through Sept. 2013.

treatment (Figure 8br). Mean canopy DGCI in plots receiving all treatment combinations containing PhysioCal, as well as the high GZ-GTO rate without PhysioCal, comprise the highest statistical grouping. Likewise, the PhysioCal treatment, applied in combination with the low rate of Fertiactyl GZ-GTO, showed significantly greater (3.3%) mean canopy color relative to the control (Figure 8br).

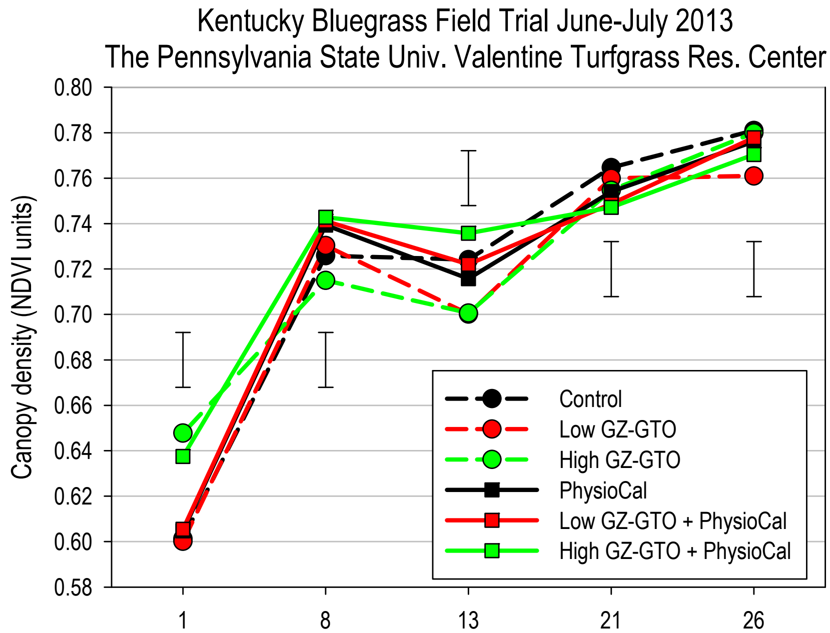
Figs. 8bl-br. Mean canopy density (bl, below left) and color (br, below right) of Kentucky bluegrass plots. Where shown (DGCI, br), means having overlapping error bars are not significantly different (alpha = 0.05).



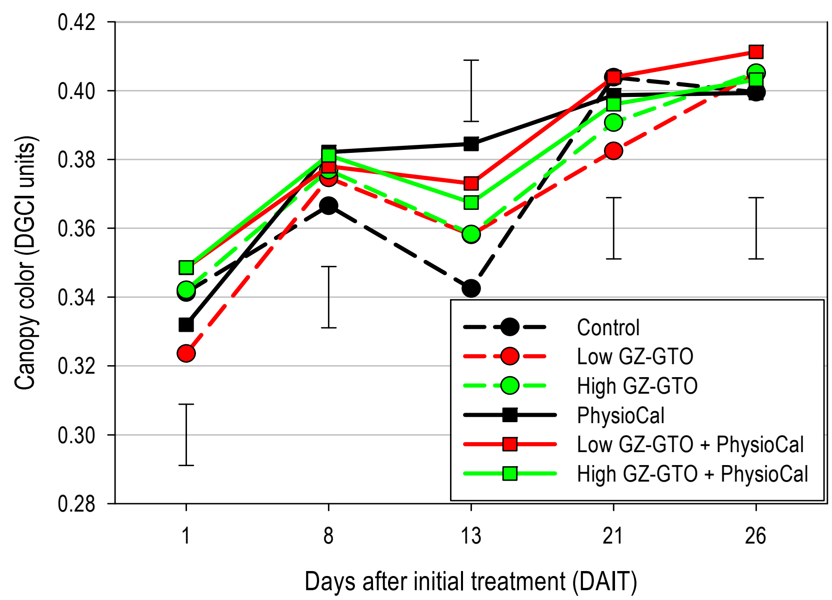
As mentioned (and shown in Figure 6), mean canopy density (NDVI) and color (DGCI) readings were indicative of a severely-trafficked and wear-damaged Kentucky bluegrass system. A clearer illustration of the initial turfgrass injury, its effects on canopy density and color, and the treatment-associated recovery is shown (Figure 9).

Levels of canopy density and color, observed 1 day after initial treatment (DAIT), were suboptimal yet representative of an intensively-trafficked system. Plots receiving the high rates of Fertiactyl (GZ-GTO) already demonstrated significantly higher canopy density than all other treatments (Figure 9a). All plots receiving the PhysioCal treatment resided within the top statistical grouping 8 DAIT. Likewise, plots treated with a combination of PhysioCal and the high rate of Fertiactyl (GZ-GTO) resided within the top statistical grouping 13 DAIT. Compared to levels observed 1 DAIT, all plots demonstrated significantly greater canopy densities 21 DAIT. This was the likely result of recuperative growth by Kentucky bluegrass maintained under conditions of optimal nutrient-availability and temperature. The NDVI levels recorded 21 and 26 DAIT are representative of a healthy and uniformly-dense Kentucky bluegrass system, and no significant differences between treatments were observed on these collection dates (Figure 9a).

Regarding canopy dark green color, all plots receiving PhysioCal treatments resided within the top statistical grouping 8 DAIT (Figure 9b). Furthermore, all plots receiving PhysioCal treatments demonstrated significantly darker green canopy color than the control plots 13 DAIT. As with later measurements of canopy density, DGCI levels recorded 21 and 26 DAIT indicate a healthy and uniformly-dense Kentucky bluegrass system, and no significant differences between treatments were observed (Figure 9b).



Figs. 9a-b. Canopy density (a, above) and color (b, below) response by days after initial treatment (DAIT). Error bars indicate the least significant difference (LSD) among treatment means (alpha = 0.05).



Kentucky Bluegrass Athletic Field Study 2: Materials & Methods

On 12 July 2013, repeated traffic/wear treatments were reapplied to Kentucky bluegrass athletic field system plots. On 15 July, the plots were further injured by a single pass of a Mataway verticutter/dethatcher (Figures 10 & 11). Liquid Fertiactyl GT-GZO applications were re-applied to the originally treated plots on 16 July in the treatment rates shown (Table right). Fertiactyl (GZ-GTO; 13-0-5) treatments were made in 50 gallons /acre carrier volume, and all treatments lightly watered in following application. PhysioCal treatments were not reapplied. Plots were mowed at a 1" height three times each week, scouted/treated for pests, and irrigated as necessary over the 56-day experimental period.

Treatment (KBAF Study 2)	Fertiactyl
(1) Control	0 oz. / M
(2) GZ-GTO Low	0.75 oz. / M
(3) GZ-GTO Low + PhysioCal	0.75 oz. / M
(4) GZ-GTO High	5.0 oz. / M
(5) GZ-GTO High + PhysioCal	5.0 oz. / M
(6) PhysioCal ONLY	0 oz. / M

Fig. 10. Application of injury/stress to plots by Mataway verticutter/dethatcher; 15 July 2013.

Beginning three days after initial treatment (3 DAIT), weekly canopy reflectance of each plot was recorded in triplicate using the described FieldScout TCM–500 turfgrass chlorophyll and color meters. Data were used to calculate NDVI (canopy density) or converted to hue, saturation, and brightness levels for dark green color index determination (canopy color).

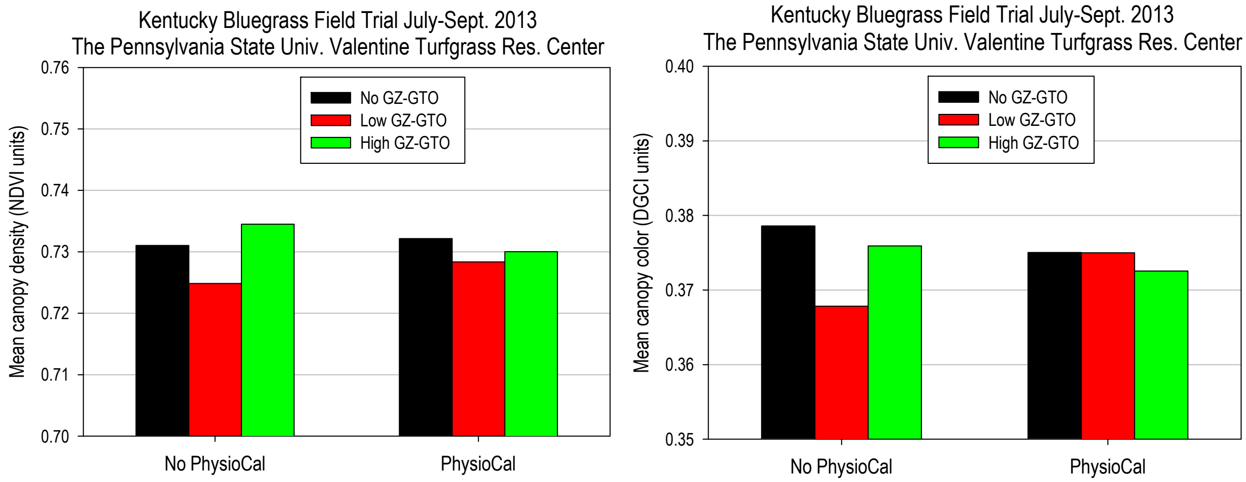
High resolution color photographs were taken of each plot 2, 3, and 4 weeks after initial treatment (WAIT). Each image was cropped to confine the plot boundary before automated analysis of percent green canopy coverage (Richardson et al., 2001) and DGCI by SigmaScan PRO Image Management Software (Ver. 5.0, SPSS Inc.).

Fig. 11. Plots following application of wear/traffic and verticutting/dethatching treatments; 15 July 2013.

Kentucky Bluegrass Athletic Field Study 2: Results

Field conditions at the time of Study 2 initiation in July were supraoptimal for Kentucky bluegrass (Figure 7). However, one week following treatment application, temperatures were significantly cooler than normal in central Pennsylvania and remained that way throughout August and into September (Figure 7). No desiccation injury was observed to result from the described Fertiactyl GZ-GTO treatment applications.

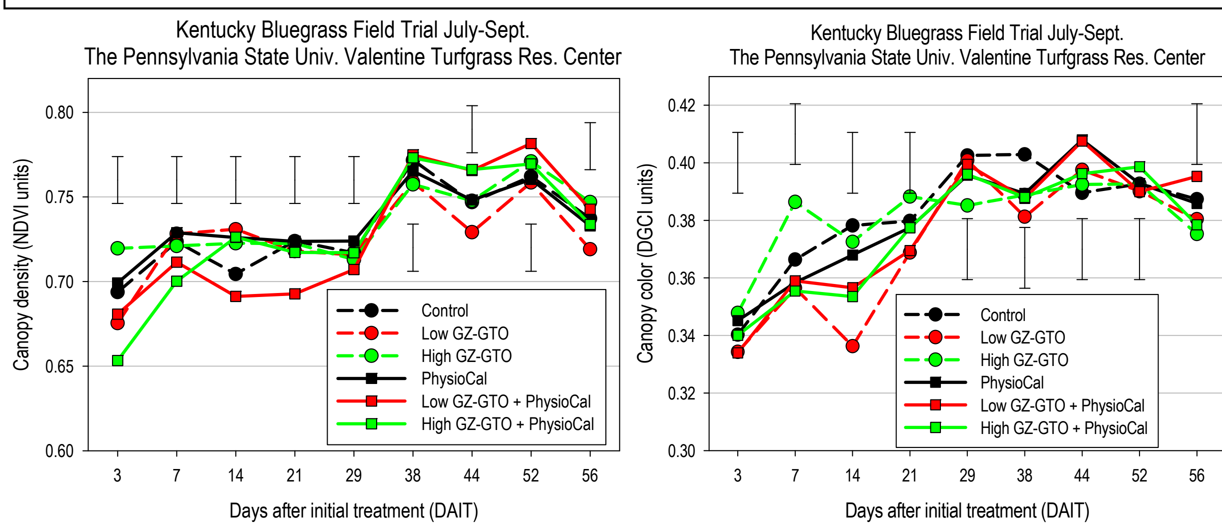
Figs. 12bl-br. Mean canopy density (bl, below left) and color (br, below right) of Kentucky bluegrass plots. No significant differences between treatments were observed.



Reflectance indices of the Kentucky bluegrass athletic field, pooled over Study 2, were low and indicative of recent injury (Figure 11). Mean canopy density (NDVI) and dark green color (DGCI) indices of the Kentucky bluegrass athletic field did not indicate a statistical effect of treatment (Figure 12). Mean canopy dark green color readings were similar to those observed in Study 1. However mean canopy density readings (NDVI) were consistently greater than Study 1 observations, particularly for treatments containing PhysioCal (Figure 12ar). This is a likely result of controlled-N release from the organic components in PhysioCal under elevated soil temperatures.

Levels of canopy density observed 3 days after initial treatment (DAIT) indicate recent injury (Figure 13bl), but not to the extent observed in Study 1. By 7 DAIT however, recorded densities were similar to those observed 8 DAIT in Study 1. The ability of the canopy reflectance spectrometers to quantify treatment differences was limited by the plot size and device sampling area. Furthermore, injury induced by the Mataway on 15 July was highly variable. While plot canopy color significantly improved over the study period (Figure 13br), the spectrometers differentiated few significant treatment differences by DAIT.

Figs. 13bl-br. Canopy density (bl, below left) and color (br, below right) response, by days after initial treatment (DAIT). Error bars indicate the least significant difference (LSD) among treatment means (alpha = 0.05).



Figs. 14bl-br. Mean canopy turf coverage (bl, below left) and image canopy color (br, below right) of Kentucky bluegrass plots. Where shown, means having overlapping error bars are not significantly different (alpha = 0.05).

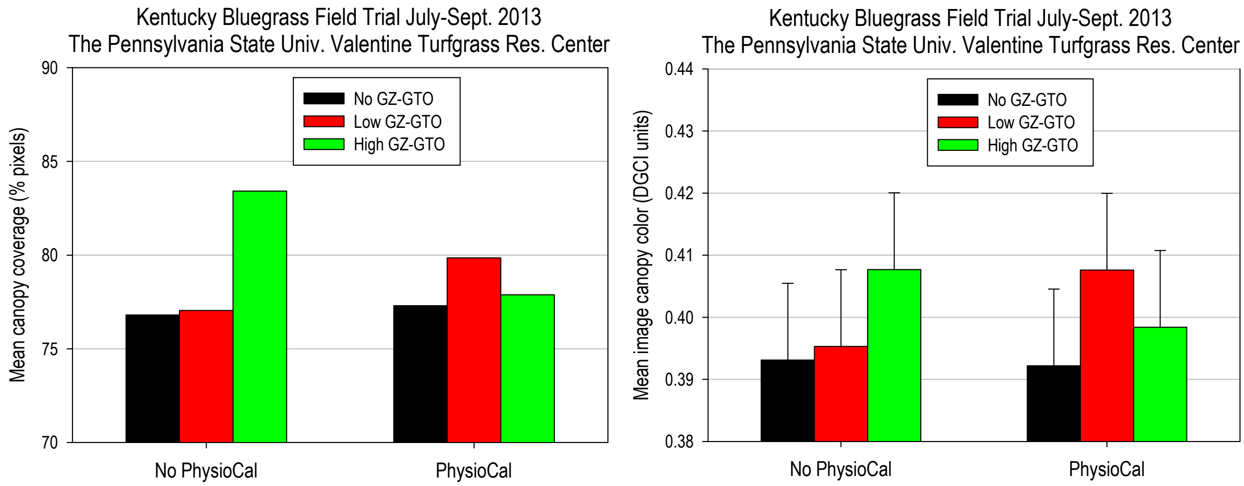
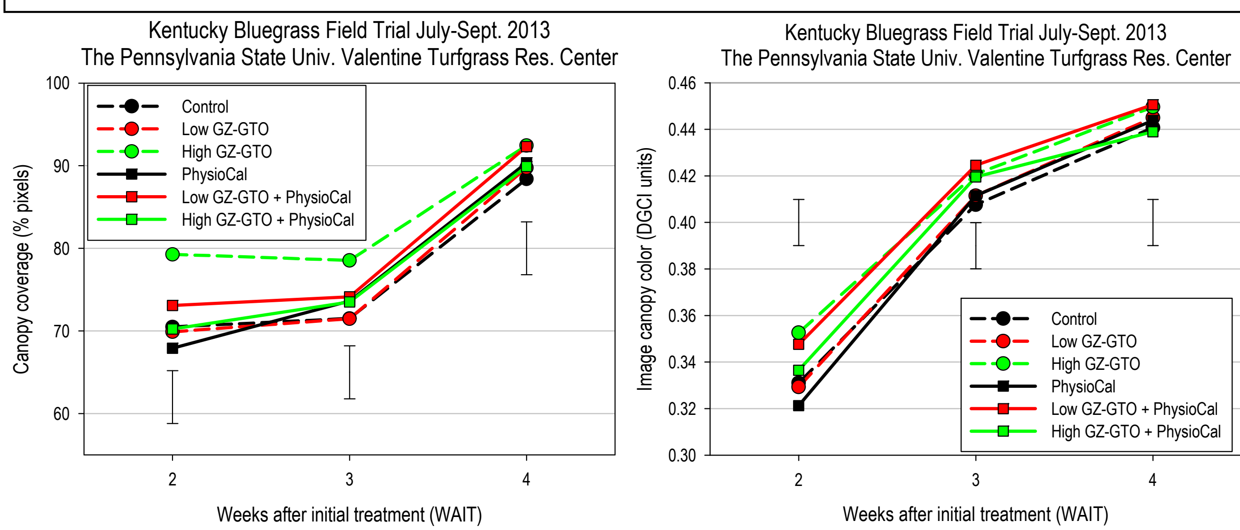


Image analysis of weekly pictures offered full-plot sample resolution and proved to be a more appropriate tool for elucidating turf recovery from injury by treatment (Figure 14) than reflectance spectroscopy in Study 2. Dark green color index of the Kentucky bluegrass athletic field was statistically influenced by treatment (Figure 14br). Mean canopy DGCI of plots receiving PhysioCal plus the low or high Fertiactyl GZ-GTO rate, as well as only the high Fertiactyl GZ-GTO rate, comprise the highest statistical grouping. Mean canopy DGCI values (by imagery) of plots receiving either the high rate of Fertiactyl GZ-GTO or the low Fertiactyl GZ-GTO rate plus PhysioCal were significantly greater (3.7%) than the control plots (Figure 14br).

Levels of imagery canopy coverage and DGCI increased by week after initial treatment (WAIT; Figure 15). Plots treated by Fertiactyl GZ-GTO at the high rate showed significantly greater canopy coverage than the control plots 2 and 3 WAIT (Figure 15bl). Likewise, plots treated by Fertiactyl GZ-GTO at the high rate showed significantly greater canopy color than the control plots 2 WAIT (Figure 15br). By 4 WAIT, no significant differences in imagery canopy coverage or DGCI were observed by treatment (Figure 15).

Figs. 15bl-br. Canopy turf coverage (bl, below left) and color (br, below right), by weeks after initial treatment (WAIT). Error bars indicate the least significant difference (LSD) among treatment means (alpha = 0.05).



Conclusions

Adequate fertility, particularly regarding nitrogen (N) and potassium (K) availability to plant roots, is an important cultural component of intensely-maintained turfgrass systems (Turner and Hummel, 1992). Likewise, availability of the primary nutrients; i.e., N, phosphorus (P), and K, is critical to the successful establishment of turfgrass. Establishment of a resilient turfgrass stand is also dependent on rapid development and continuing health of a deep and extensive root system. For that reason, readily available levels of soil calcium that support cell division and cell wall construction are needed.

The results of the described greenhouse turf-type tall fescue establishment study confirm the importance of adequate nutrition in rapid establishment of a turfgrass stand. Repeat applications of Fertiactyl GZ-GTO (13-0-5) at a 0.75 oz. product per M (1000 ft^2) rate within 44 days of seeding (totaling 1.5 oz. product / M), combined with a 10 lbs / M pre-seeding application of PhysioCal (3-0-0, 23% Ca), resulted in significantly increased shoot growth/clipping yield (39%) and root length density (19%) compared to the untreated control. While the exact role of associated seaweed extract and zeatin components in PhysioCal and Fertiactyl GZ-GTO were not evaluated in this study, dependable recurrence of the observed above- and below-ground growth responses in the field would certainly be considered favorable by turfgrass managers establishing turf-type tall fescue.

Considering utility and recreation are perhaps the two most important functions of a turfgrass system, cultural practice that supports rapid recovery from injury by traffic, wear, and/or physical cultivation is of interest to turfgrass managers. While the imposed injury may not be fully-representative of all systems and/or uses, the results of the Kentucky bluegrass athletic field studies described indicate immediate Fertiactyl GZ-GTO treatment may enhance Kentucky bluegrass canopy color and coverage (recovery) in the weeks following injury. Furthermore, this recovery may be enhanced by soil conditioning with PhysioCal at label rates. Further research of the described products will add to the current knowledge base and strengthen our understanding of how edaphic, environmental, and cultural conditions influence turfgrass response to their use.

Disclaimer

Trade and/or manufacturer's names mentioned in this report are for information only and do not constitute endorsement, recommendation, or exclusion by the authors or the Pennsylvania State University. Above-mentioned turfgrass responses resulted from treatment applications to specific sites SOLELY AS DESCRIBED herein, and as allowed by regulations governing agronomic use of such materials.

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