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The Rutgers Turfgrass Proceedings is published yearly by the Rutgers Center for Turfgrass Science, Rutgers Cooperative Extension, and the New Jersey Agricultural Experiment Station, School of Environmental and Biological Sciences, Rutgers, The State University of New Jersey in cooperation with the New Jersey Turfgrass Association. The purpose of this document is to provide a forum for the dissemination of information and the exchange of ideas and knowledge. The proceedings provide turfgrass managers, research scientists, extension specialists, and industry personnel with opportunities to communicate with co-workers. Through this forum, these professionals also reach a more general audience, which includes the public.

This publication includes lecture notes of papers presented at the 2013 GREEN EXPO Turf and Landscape Conference. Publication of these lectures provides a readily available source of information covering a wide range of topics and includes technical and popular presentations of importance to the turfgrass industry.

This proceedings also includes research papers that contain original research findings and reviews of selected subjects in turfgrass science. These papers are presented primarily to facilitate the timely dissemination of original turfgrass research for use by the turfgrass industry.

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Dr. Ann Brooks Gould, Editor
Dr. Bruce B. Clarke, Coordinator

# IMPROVEMENT OF COMPACTED SOIL WITH TILLAGE AND LEAF COMPOST

**James A. Murphy and Charles J. Schmid[1]**

Severe compaction of soil with heavy construction equipment is a common problem of developed land, making it difficult to establish and sustain soil cover with turfgrass and other plantings. Soil compaction is the destruction of soil particles that results in a more dense soil mass with less pore space (Carrow and Petrovic, 1992). Compacted soils have increased soil strength, which impedes root growth, decreased soil aeration (limited $O_2$), decreased infiltration and percolation rates, and excessive moisture retention (Carrow and Petrovic, 1992). Soil tillage is typically used to decrease compaction prior to the establishment of turfgrass.

The availability and application of compost products to turfgrass systems has dramatically increased over the past two decades (Bigelow and Soldat, 2013). Incorporation of organic amendments into a soil can improve both physical (soil structure, soil porosity, and density) and chemical (CEC) properties (McCoy, 1998). Previous studies have reported that compost incorporation into the soil can reduce turfgrass establishment time (Gentilucci et al., 2001; Loschinkohl and Boehm, 2001; Schnell et al., 2009). However, composts with high C:N ratio can result in poor turfgrass establishment due to nutrient imbalances (Gentilucci et al., 2001) The objective of this field study was to determine the effects of tillage to reduce soil compaction and amending to increase the soil organic matter (SOM) on the establishment and survival of a low maintenance turfgrass cover.

## MATERIALS AND METHODS

### Site Preparation and Establishment

Soil testing assessments identified a sandy loam at Jakes Branch County Park in Beachwood NJ that was severely compacted, acidic, and low in P, K, Ca, and Mg (Table 1). The SOM content was 1.53%, by weight, which is considered a medium level for sandy loam.

Four soil treatments consisting of two levels of tillage and three levels of organic matter amendment were applied to the sandy loam in a randomized complete block design with 4 replications. Due to space limitations it was not feasible to evaluate all combinations of these factors. Treatments included no soil improvements (control), tillage, tillage with leaf compost to increase SOM to 2.5%, and tillage with leaf compost to increase SOM to 5.0% (Table 2).

The trial site area was prepared by removing and stockpiling the topsoil-like layer (about 1-inch depth). The subsoil was graded to produce a smooth slope and rolled to firm, after which the topsoil was replaced over the trial area and loosened with a Harley rake. These actions represent typical soil preparation methods for landscaping and represent the physical preparation of soil for the control treatment (#1).

Sixteen 8- x 20-ft plots were marked to serve as guides for tillage equipment. All treatments that received tillage were ripped three times with a subsoiler (1.5 to 2 ft apart) to a 12-inch depth, which broke up the soil surface into large clods. A Rotadairon® (5-ft swath) was used to till the large soil clods at the surface 6-inch depth into finer clods. The tiller approximately treated the center 6 feet of each 8-ft wide plot.

After this initial tillage, dolomitic lime, phosphate (0-46-0), and potash (0-0-50) were applied, based on soil test results, at 4.2, 4.7, and 6.1 lb per 1000 $ft^2$, respectively, over the trial site.

[1]Extension Specialist in Turfgrass Management and Graduate Assistant, respectively, New Jersey Agricultural Experiment Station, School of Environmental and Biological Sciences, Rutgers, The State University of New Jersey, New Brunswick, NJ 08901-8520.

After fertilization, the two treatment levels of leaf compost were incorporated into the sandy loam. The chemical properties of the leaf compost utilized in this study are listed in Table 1. Leaf compost was spread at 61 and 242 $ft^3$ per 1000 $ft^2$ (Table 2) over the center 6-ft swath of respective plots, after which all tillage plots were tilled with 2 passes of a Rotadairon® tiller. The plots receiving the greatest organic matter amendment rate, 242 $ft^3$ per 1000 $ft^2$, required a split-application of leaf compost and another two passes of the tiller to incorporate.

The trial site was fertilized and seeded with three varieties of turfgrass on 25 September 2012. OceanGro (5-5-0) fertilizer was applied to the entire trial area at 1 lb of N and available phosphate per 1000 $ft^2$. Bullseye tall fescue, Spyder LS tall fescue, and Heron hard fescue were seeded at 3.1, 3.3, and 2.5 lb per 1000 $ft^2$, respectively.

### Data Collection and Analysis

After seeding, turfgrass establishment (% cover) was rated periodically from October 2012 through September 2013. Turf quality (1 to 9 scale; 9 = highest rating) and turf color (1 to 9 scale; 9 = highest rating) were rated periodically during fall 2012 and throughout 2013. Soil volumetric water content and bulk density were measured with a Troxler (Model 3411-B; Troxler Electronic Labs, Inc., Research Triangle Park, NC) surface moisture-density guage operated in the backscatter mode.

Soil samples were collected on 22 October 2013 to assess SOM, pH, and nutrient availability. Four samples per plot were collected with a 1.25-inch sample tube to a depth of 6.7 inches. Organic matter content was determined by the loss on ignition (LOI) method (Nelson and Sommers, 1996). Nutrient availablility (P, K, Ca, and Mg) were extracted by the Mehlich 3 method (Mehlich, 1984).

Analysis of variance was performed on data using a randomized complete block design. Means were separated using Fisher's protected least significant difference (LSD) test at $p \leq 0.05$. Orthogonal contrasts were used to compare no tillage vs. tillage, not amended vs. amended, and amended to 2.5% organic matter vs. amended to 5.0% organic matter.

## RESULTS AND DISCUSSION

### Establishment and Turf Cover

Tillage and amendment of soil with leaf compost influenced the establishment of the turf. Initially, tillage and amending with leaf compost had a limited or negative effect on establishment (Table 3). This was likely due to the greater concentration of nutrients at the soil surface nearest seedling plants in the non-tilled, non-amended plots compared to other treatments. Additionally, the high C:N ratio (41) of the leaf compost caused symptoms of nitrogen deficiency in the turf plants (see turf color data in Table 4) and delayed establishment compared to non amended plots. Gentilucci et al. (2001) observed that incorporation of municipal solid waste co-compost with a C:N ratio of 42 caused poor germination of Kentucky bluegrass (*Poa pratensis* L.) in a highly eroded sandy loam.

Improved turf cover with tillage and amending were apparent by May 2013. Turf cover of the plots receiving tillage only and amended with 61 $ft^3$ per 1000 $ft^2$ leaf compost averaged about 90% by June 2013, which represented an increase in turf cover of 16% on average compared to the non-tilled treatment. The negative effect of the C:N ratio was still evident in June 2013 on the plots amended with 242 $ft^3$ per 1000 $ft^2$ of leaf compost; turf cover was about 10% lower in this treatment compared to the plots treated with tillage only and leaf compost at 61 $ft^3$ per 1000 $ft^2$. Turf cover in the non-tilled, non-amended plots was significantly decreased by August 2013 due to drought stress during July 2013. Drought stress had less of an effect on tillage only and amended plots, having only slightly decreased turf cover by August 2013.

### Turf Color and Turf Quality

Turf color of plots amended with leaf compost at 242 $ft^3$ per 1000 $ft^2$ was lower than all other treatments throughout 2012 and 2013 (Table 4). This was likely due to reduced nitrogen availability in the soil caused by the high C:N ratio in the leaf compost and increased microbial activity.

Turf quality was generally better on plots receiving soil improvement treatments; however, the quality of plots amended with leaf compost at 242 $ft^3$ per 1000 $ft^2$ lagged behind the tillage only and 61 $ft^3$ per 1000 $ft^2$ leaf compost treatments (Table 5). This was attributed to the leaf compost having a C:N ratio that was greater than recommended. By August 2013, turf quality of the non-tilled, non-amended plots was significantly decreased compared to the tillage only and amended plots.

**Soil Volumetric Water Content and Bulk Density**

Drought stress was evident during the June evaluation of the trial and visual observations of wilt clearly indicated that the non-tilled treatment was experiencing greater drought stress than the soil improvement treatments (data not shown). Measurements of soil volumetric water content in 2013 indicated that soil improvement treatments increased water holding capacity of the soil (Table 6). Amending the sandy loam with leaf compost at 242 $ft^3$ per 1000 $ft^2$ increased volumetric water content by 0.11 and 0.08 $ft^3$ per $ft^3$ of soil in May and June, respectively, compared to the non-tilled treatment.

Tillage and amending soil with leaf compost reduced the bulk density of the sandy loam (Table 6). The greatest reduction in soil bulk density was observed in the sandy loam amended with leaf compost at 242 $ft^3$ per 1000 $ft^2$, which decreased bulk density by 26, 23, and 24 lb per $ft^3$ in May, June, and July, respectively, compared to the non-tilled treatment.

**Soil Fertility**

Soil nutrients (except K) were greater in all leaf compost amended plots compared to non-tilled, non-amended and tillage only, and increased as the rate of amendment increased (Table 7). Amending soil with leaf compost at 61 and 242 $ft^3$ per 1000 $ft^2$ resulted in SOM contents of 3.0 and 5.5%, respectively. As expected, SOM increased at the higher rate of leaf compost. Soil pH was also influenced by compost; plots that received leaf compost had a higher soil pH than non-amended plots.

## CONCLUSIONS

Tillage improved the physical properties of the severely compacted soil, which limited drought stress on the turf during summer months. Increases in SOM with leaf compost amendment further decreased bulk density and increased water holding capacity. Soil fertility was also improved by amending the soil with leaf compost; however, an imbalance in the carbon and nitrogen content of the leaf compost initially limited turf establishment when the leaf compost was applied at the highest rate. The decrease in overall performance caused by the high C:N ratio in the leaf compost slowly diminished over time. Tillage and compost amendment are effective methods for improving compacted soils for establishing and maintaining turf. Care should be taken in selecting uniform and mature compost.

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Table 1. Chemical properties of sandy loam and leaf compost amendment utilized in the establishment of tall fescue and fine fescue turf at Jakes Branch County Park in Beachwood, NJ.

| Material | pH | EC[1] | OM[2] | N[3] | P[4] | K | Ca | Mg | C:N ratio |
|---|---|---|---|---|---|---|---|---|---|
| | | mmhos/cm | ---------%--------- | | ----------------lb per A[5]---------------- | | | | |
| Sandy loam | 5.27 | n.d.[6] | 1.5 | n.d. | 49 | 43 | 100 | 675 | n.d. |
| Leaf compost | 6.9 | 0.41 | 46.3 | 1.14 | 18 | 32 | 23 | 8 | 41 |

[1]Electrical conductivity
[2]Organic matter determine by loss on ignition (Nelson and Sommers, 1996)
[3]Total N determined by Kjeldahl method (Bremner, 1996)
[4]P, K, Ca, and Mg extracted by Mehlich 3 method (Mehlich, 1984)
[5]1 ppm = 2 lb per A
[6]not determined

Table 2. Summary of the levels of tillage and organic matter amendment of four treatments evaluated on sandy loam at Jakes Branch County Park in Beachwood, NJ.

| Treatment No. | Tillage | Organic Matter Amendment |
|---|---|---|
| 1 | None | None |
| 2 | Subsoiler and Rotadairon® | None |
| 3 | Subsoiler and Rotadairon® | 61 $ft^3$ of leaf compost per 1000 $ft^2$ |
| 4 | Subsoiler and Rotadairon® | 242 $ft^3$ of leaf compost per 1000 $ft^2$ |

Table 3. Tillage and leaf compost effects on the establishment of a turfgrass mixture (tall fescue and hard fescue) seeded on 25 September 2012 on a sandy loam at Jakes Branch County Park in Beachwood, NJ.

| | Treatment Factors | | Turf Cover[1] 2012 | | | Turf Cover 2013 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tillage[2] | Leaf Compost[3] | 18 Oct. | 19 Nov. | 19 Dec. | 4 March | 9 May | 23 June | 4 Aug. | 3 Sept. |
| | | ft³ per 1000 ft² | % | | | | | | | |
| 1 | None | 0 | 28 | 48 | 73 | 69 | 56 | 73 | 28 | 38 |
| 2 | Yes | 0 | 38 | 44 | 61 | 58 | 74 | 91 | 90 | 80 |
| 3 | Yes | 61 | 28 | 34 | 50 | 50 | 66 | 88 | 83 | 78 |
| 4 | Yes | 242 | 26 | 31 | 46 | 40 | 61 | 79 | 78 | 74 |
| | Orthogonal contrasts | | | | | | | | | |
| | Treatment 1 vs. 2, 3, 4 | | NS | ** | *** | *** | * | ** | *** | *** |
| | Treatment 2 vs. 3, 4 | | ** | ** | *** | *** | * | * | NS | NS |
| | Treatment 3 vs. 4 | | NS | NS | NS | ** | NS | * | NS | NS |
| | CV (%) | | 13.2 | 13.9 | 5.0 | 6.6 | 9.9 | 6.1 | 11.8 | 11.2 |

[1] 100% = fullest cover

[2] Tillage included three passes (1.5 to 2.0 ft apart) of a subsoiler to a 12-inch depth after which a Rotadairon® rototiller (5-ft swath) was operated twice over each plot treating approximately the center 6 feet of each plot

[3] Leaf compost applied as one application at 61 ft³ per 1000 ft² or as two split applications of 242 ft³ per 1000 ft². All tillage plots received 2 passes of a Rotadairon® tiller after each application of leaf compost

Table 4. Tillage and leaf compost effects on the turf color of a turfgrass mixture (tall fescue and hard fescue) seeded on 25 September 2012 on a sandy loam at Jakes Branch County Park in Beachwood, NJ.

| | Treatment Factors | | Turf Color[1] 2012 | | | Turf Color 2013 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tillage[2] | Leaf Compost[3] | 18 Oct. | 19 Nov. | 19 Dec. | 4 March | 9 May | 23 June | 4 Aug. | 3 Sept. |
| | | $ft^3$ per 1000 $ft^2$ | --------1 to 9 scale-------- | | | | | | | |
| 1 | None | 0 | 6.8 | 5.3 | 6.8 | 4.8 | 3.5 | 6.5 | 7.0 | 6.0 |
| 2 | Yes | 0 | 7.8 | 5.8 | 6.3 | 5.5 | 5.5 | 7.5 | 4.5 | 4.8 |
| 3 | Yes | 61 | 6.3 | 5.3 | 5.8 | 5.0 | 5.3 | 6.5 | 6.3 | 5.5 |
| 4 | Yes | 242 | 6.0 | 4.5 | 4.5 | 4.0 | 3.8 | 5.0 | 4.3 | 4.0 |
| | Orthogonal contrasts | | | | | | | | | |
| | Treatment 1 vs. 2, 3, 4 | | NS | NS | ** | NS | ** | NS | *** | ** |
| | Treatment 2 vs. 3, 4 | | *** | ** | ** | * | * | *** | NS | NS |
| | Treatment 3 vs. 4 | | NS | * | ** | * | ** | *** | ** | ** |
| | CV (%) | | 5.1 | 8.1 | 9.2 | 12.1 | 12.8 | 6.9 | 11.3 | 10.5 |

[1] 9 = dark green color; 5 = acceptable color

[2] Tillage included three passes (1.5 to 2.0 ft apart) of a subsoiler to a 12-inch depth after which a Rotadairon® rototiller (5-ft swath) was operated twice over each plot treating approximately the center 6 feet of each plot

[3] Leaf compost applied as one application at 61 $ft^3$ per 1000 $ft^2$ or as two split applications of 242 $ft^3$ per 1000 $ft^2$. All tillage plots received 2 passes of a Rotadairon® tiller after each application of leaf compost

Table 5. Tillage and leaf compost effects on the turf quality of a turfgrass mixture (tall fescue and hard fescue) seeded on 25 September 2012 on a sandy loam at Jakes Branch County Park in Beachwood, NJ during 2013.

| | Treatment Factors | | Turf Quality[1] 2013 | | | |
|---|---|---|---|---|---|---|
| | Tillage[2] | Leaf Compost[3] | 9 May | 23 June | 14 Aug. | 3 Sept. |
| | | $ft^3$ per 1000 $ft^2$ | ----------1 to 9 scale---------- | | | |
| 1 | None | 0 | 2.8 | 5.0 | 2.0 | 2.0 |
| 2 | Yes | 0 | 4.3 | 6.8 | 5.8 | 5.0 |
| 3 | Yes | 61 | 4.0 | 6.5 | 5.8 | 5.5 |
| 4 | Yes | 242 | 3.0 | 4.8 | 5.0 | 4.3 |
| | Orthogonal contrasts | | | | | |
| | Treatment 1 vs. 2, 3, 4 | | * | * | *** | *** |
| | Treatment 2 vs. 3, 4 | | NS | * | NS | NS |
| | Treatment 3 vs. 4 | | * | ** | NS | * |
| | CV (%) | | 16.5 | 12.3 | 20.7 | 17.9 |

[1] 9 = best turf quality; 5 = acceptable quality

[2] Tillage included three passes (1.5 to 2.0 ft apart) of a subsoiler to a 12-inch depth after which a Rotadairon® rototiller (5-ft swath) was operated twice over each plot treating approximately the center 6 feet of each plot

[3] Leaf compost applied as one application at 61 $ft^3$ per 1000 $ft^2$ or as two split applications of 242 $ft^3$ per 1000 $ft^2$. All tillage plots received 2 passes of a Rotadairon® tiller after each application of leaf compost

Table 6. Tillage and leaf compost effects on the soil volumetric water content and bulk density of a turfgrass mixture (tall fescue and hard fescue) grown on a sandy loam at Jakes Branch County Park in Beachwood, NJ during 2013.

| | Treatment Factors | | Volumetric Water Content[1] | | | Bulk Density[1] | | |
|---|---|---|---|---|---|---|---|---|
| | Tillage[2] | Leaf Compost[3] | 9 May | 23 June | 13 Aug. | 9 May | 23 June | 13 Aug. |
| | | $ft^3$ per 1000 $ft^2$ | ----------------$ft^3$ per $ft^3$---------------- | | | ----------------lb per $ft^3$---------------- | | |
| 1 | None | 0 | 0.21 | 0.13 | 0.23 | 86 | 80 | 82 |
| 2 | Yes | 0 | 0.20 | 0.13 | 0.20 | 84 | 74 | 72 |
| 3 | Yes | 61 | 0.23 | 0.15 | 0.21 | 76 | 70 | 68 |
| 4 | Yes | 242 | 0.32 | 0.21 | 0.23 | 60 | 57 | 58 |
| | Orthogonal contrasts | | | | | | | |
| | Treatment 1 vs. 2, 3, 4 | | * | * | NS | *** | *** | *** |
| | Treatment 2 vs. 3, 4 | | *** | ** | NS | *** | *** | *** |
| | Treatment 3 vs. 4 | | *** | ** | NS | *** | *** | *** |
| | CV (%) | | 9.4 | 15.6 | 15.3 | 3.3 | 3.8 | 3.3 |

[1] Volumetric water content and bulk density measured with a Troxler (Model 3411-B) surface moisture-density gage in the backscatter mode

[2] Tillage included three passes (1.5 to 2.0 ft apart) of a subsoiler to a 12-inch depth after which a Rotadairon® rototiller (5-ft swath) was operated twice over each plot treating approximately the center 6 feet of each plot

[3] Leaf compost applied as one application at 61 $ft^3$ per 1000 $ft^2$ or as two split applications of 242 $ft^3$ per 1000 $ft^2$. All tillage plots received 2 passes of a Rotadairon® tiller after each application of leaf compost

Table 7. Soil tillage and amendment effects on soil organic matter, pH, and nutrient availability of tall fescue/fine fescue turf in Beachwood, NJ.

| | Treatment Factors | | 22 Oct. 2013 | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Tillage[1] | Leaf Compost[2] | SOM[3] | pH | P | K | Ca | Mg |
| | | $ft^3$ per 1000 $ft^2$ | ---%--- | | ------------------------lb per acre[4]----------------------- | | | |
| 1 | None | 0 | 2.0 | 5.2 | 83 | 105 | 833 | 126 |
| 2 | Yes | 0 | 1.6 | 5.6 | 74 | 102 | 775 | 176 |
| 3 | Yes | 61 | 3.0 | 5.8 | 98 | 117 | 1646 | 284 |
| 4 | Yes | 242 | 5.5 | 5.9 | 121 | 137 | 2615 | 428 |
| | Orthogonal contrasts | | | | | | | |
| | Treatment 1 vs. 2, 3, 4 | | ** | *** | NS | NS | *** | *** |
| | Treatment 2 vs. 3, 4 | | *** | * | * | NS | *** | *** |
| | Treatment 3 vs. 4 | | *** | NS | NS | NS | *** | *** |
| | CV (%) | | 21.2 | 2.7 | 20.3 | 18.7 | 16.4 | 10.4 |

[1] Tillage included three passes (1.5 to 2.0 ft apart) of a subsoiler to a 12-inch depth after which a Rotadairon® rototiller (5-ft swath) was operated twice over each plot treating approximately the center 6 feet of each plot

[2] Leaf compost applied as one application at 61 $ft^3$ per 1000 $ft^2$ or as two split applications of 242 $ft^3$ per 1000 $ft^2$. All tillage plots received 2 passes of a Rotadairon® tiller after each application of leaf compost

[3] Soil organic matter determined by loss on ignition (Nelson and Sommers, 1996)

[4] P, K, Ca, and Mg extracted by Mehlich 3 method (Mehlich, 1984); 1 ppm = 2 lb per acre