A Comparative Study of Composted Organic Wastes and IBDU Fertilizer in Nitrogen Utilization by Bentgrass Cultivars

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A COMPARITIVE STUDY OF COMPOSTED ORGANIC WASTES
AND IBDU FERTILIZER IN NITROGEN UTILIZATION
BY BENTGRASS CULTIVARS

A Thesis
Presented to
the Faculty of the Department of Agriculture
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In Partial Fulfillment
of the Requirements for the Degree
Master of Science

By
David Aaron Mathews
August 2001
A COMPARITIVE STUDY OF COMPOSTED ORGANIC WASTES
AND IBDU FERTILIZER IN NITROGEN UTILIZATION
BY BENTGRASS CULTIVARS

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A COMPARITIVE STUDY OF COMPOSTED ORGANIC WASTES AND IBDU FERTILIZER UTILIZATION BY BENTGRASS CULTIVARS

Aaron Mathews

Directed by: Dr. Haibo Liu, Dr. William T. Willian, and Dr. Rebecca Gilfillen

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This research project that was conducted to provide evidence that composted organic waste materials do provide comparable nitrogen absorption efficiency in relation to an organic slow release fertilizer. Western’s compost facility supplied the two different organic wastes, which had been composted for 1 year. The materials used were composted urban leaf litter, sawdust/manure mixture at a 50/50 ratio by volume and an organic fertilizer IBDU. These materials were applied to one cultivars of (Agrostis capillaries) and three cultivars of (A. palustris) at the rate of .5lb/1000 sq in the months of April, June, and September. The plots were sampled one month after application to evaluate the nitrogen concentration of the leaf and thatch material. The nitrogen concentration was measured by using a Leco 2000 CHN provided in the Dept. of Chemistry. In comparison of N recovery in leaves, “Exeter” had lower N concentration than the other cultivars in October and no difference in May and July of the first year. The leaf concentration for the second year showed that Penncross and L-93 were lower in May and were the same for the other two sample dates. There was no difference found in the N concentration of thatch among the fertilizer sources for both years. IBDU showed better N recovery in all but the last sample date where all treatments were the same.
INTRODUCTION

This research project was initiated in the spring of 1999 on established bentgrass turf plots. The location was at the Charles Taylor Turf Research Station on the Western Kentucky University farm in Bowling Green, Kentucky. This project was initiated to study the nitrogen utilization from 3 fertilizer sources utilizing 4 different cultivars of bentgrass to determine how composted organic waste compares to a commercially available IBDU fertilizer. The second portion of this study was designed to evaluate 4 cultivars of bentgrass to help determine which cultivars have potential to survive in a fairway setting located in the transition zone.

Both portions of this study were conducted throughout the growing seasons of 1999 and 2000, which were both severe drought seasons. This moisture deficit had an impact on both portions of the study, but the cultivar evaluations suffered more significantly. The purpose of this research was to determine the true value of composted organic waste and to find a productive use for these waste products. Through this study some knowledge was gained pertaining to extreme environmental conditions and their effects on the quality of bentgrass fairway turf. Some information may be garnered from this experiment that could be used in the selection of bentgrasses that can withstand the extremes of the transition zone.
LITERATURE REVIEW

Using organic amendments is not new; people have been using them in one form or another for centuries. By utilizing organic amendments earlier people were able to improve some earlier crops. Whether the use of the organic amendment was to improve corn (Zea mays) production by placing whole fish in the root zone or by spreading bone meal around roses (Rosa spp.) for healthier blooms, organic use has always been present (Wilkinson, 1994; Wong, 1997).

For many years, the use of organics was the only way to improve the soil productivity by providing the nutrients for a fruitful harvest. After many years of refinement, isolation and concentration of the mineral elements that plants need and use, the modern fertilizer technique has been developed (Wilkinson, 1994). Just by reviewing the broad array of fertilizer products on the market, any nutrient a crop needs can be purchased. The fertilizer industry can chemically isolate and concentrate any element needed for a plant to live and thrive. If any of the 16 essential crop elements are lacking, the element can be purchased and applied in a useable form to the area that is deficient, (Graham, 1997; Nelson, 1996).

Improper use of fertilizers can result in a negative impact on the environment and a waste of money (USDA, 1991; Strebel et. al., 1989). Production of these fertilizers is expensive. For example, producing 1kg. of useable nitrogen through the Harbor-Bosch method requires 1.5 kg of nonrenewable fossil fuel for its production (Bacon, 1995). The total need for nitrogen fertilizers requires approximately 2% of all the natural gas for the manufacturing (The Rodale Book of Composting, 1992). So, when nitrogen is
excessively applied the result is pollution of ground water through runoff and leaching as well as pollution of the atmosphere through excessive burning of fossil fuels (Strebel, Duynisveld, Bottcher, 1989).

All fertilizers are absorbed as inorganic elements and many commercially produced fertilizers are in an organic state, Therefore bringing up the question what is an organic fertilizer? According to the Association of American Plant Fertilizer Control Officials (AAPFCO), natural organic nitrogen sources are materials derived from either plant or animal products containing one or more elements (other than carbon, hydrogen and oxygen) that are essential for plant growth. These materials may be subjected to biological degradation processes under normal conditions of aging, rainfall, sun curing, air-drying, composting, rotting, enzymatic, anaerobic or aerobic bacterial action, or any combination of these. These materials shall not be mixed with synthetic materials or changed in any physical or chemical matter from their initial state except by physical manipulation such as drying, cooking, grinding, shredding or pelleting. The utilization of these sources in their legally stated form can be constituted as being organic and environmentally sound.

There is an economical compromise, both monetarily and environmentally, between the use of inorganic fertilizers and organic fertilizers. Some large-scale utilization of organics is already in progress. Many agricultural crop growers have taken steps for many crops to incorporate organic matter into the soil from which they received their last harvest. The meaning is simply using chaff, stubble, and even planting green manure crops to add organic matter into the soil, rather than taking all that it offers.
For years golf course greens have been artificial or manmade by blending up a profile of 12” to 14” of root-zone mixture consisting of 80% sand and 20% peat moss for the organic material to create optimal growing conditions (Turgeon, 1999). Some tees have also been artificially fabricated by creating a profile of sand, soil, and organic material to create optimal growing conditions. However, most tees and nearly all fairways are native soils. Many new golf courses are pushing into less desirable areas due to expanding population. Many native soils are less than optimal and in need of soil amendments. There is less organic matter and lower microbial populations in some of these less favorable areas. By not having the microbial decomposition of organic matter, there are less stabilized nutrients and less valuable soil both horticulturally and agronomically (Wilkinson, 1994; Landschoot, 1998).

It has been stated that the use of synthetic fertilizers and pesticides reduces or eliminates the microbial community by causing either direct or indirect toxicity to these organisms. Their use is speculated to cause lower numbers of beneficial microorganisms in the soil (Nelson, 1998). If those speculations were true it would further complicate the problem of claiming less favorable growing media. Opposing these speculations is one ongoing study that indicates that pesticides do not adversely affect most non-target microorganisms (Nelson, 1996). This aspect of spraying chemicals is still not clear and can only be disputed until more evidence can be compiled. It has also been stated that due to the high productivity and rapid turnover of turfgrass roots, as well as the high lignin content in the stems and leaves, organic matter and microbial habitats are rarely deficient in a turfgrass system (Loomis, Connor, 1992).
This point would hold true to areas that have proper environmental conditions for sustaining substantial turf growth that in turn would sustain a healthy microbial population. The same may not hold true to areas that have only marginal turf growth and that lack the high productivity and rapid turn over of roots, stems and leaves. A study of humates and humic acid showed that by their use, the cation exchange capacity (CEC) rate of the root zone mix could be increased by 13%. This study used commercially available products, and the cost was rather expensive for the amount of change achieved (Kussow, 1994). The humates and humic acids are the end result of the decomposition of organic matter. By being able to utilize the nature of organics to boost organic matter, microbial populations, nutrition and the CEC of the soil would be beneficial both economically and environmentally (Landschoot, 1998; Nelson, 1996; Senseman, 1995).

Other literature has shown that increased microbial populations could reduce the occurrences of certain diseases. Numerous studies have been conducted on the utilization of organic amendments to reduce the occurrence of disease. Data combined by the Bayer Agriculture Division showed that, ranked by crop, turf was the biggest user of fungicide.
The high demand for fungicide on golf courses causes a great interest in research to identify alternative ways to reduce fungicide use (Fig. 1). There has been substantial research in this area, finding out how and why the use of certain organic amendments decreases the occurrence of some fungal diseases. The utilization of compost is one of the most promising uses of organic matter to reduce the occurrence of many undesirable fungi (Nelson, 1996; Senseman, 1995).

Compost has many positive benefits. It is known that compost supports high numbers of microorganisms, and through their use the number of microorganisms in the soil profile can be boosted (Nelson, M., 2000; Meyer and Smejkal, 1994). By increasing the number of microorganisms in the soil profile a suppressive factor is stimulated. It has been shown that the utilization of some compost has the suppressiveness of some chemical fungicides. In a case study of pythium root rot (Pythium graminicola) in
established turf grasses, Nelson was able to show the suppressiveness of compost made from fowl--mainly chicken and turkey--manure compost. These composts showed far greater suppression of *Pythium graminicola* and dollar spot (*Sclerotinia homeocarpa*) compared to compost of peat, MH cow manure, Baltimore biosolids and spent mushrooms (Nelson et al., 1994). In at least one case study there has also been a show of suppression of even harmful populations of lance (*Hoplolaimus spp.*), sting (*Belonoaimus spp.*) and ring (*Criconemella spp.*) nematodes (Nutter and Christie, 1958). Some of these suppressions come from the increased actinomycete population, which produce antibiotics that are harmful to many of these disease causing and other microorganisms (Nelson, 1997; Stockwell et al., 1994; Meyer and Smejkal, 1994). Suppressing or eliminating some of the problematic organisms can maintain equilibrium established where one microorganism does not dominate the total population (Hartz et al., 1996).

The majority of the studies have centered on disease and disease suppression which is understandable given the amount of time, energy and money spent to battle those disease causing fungi (Nelson, 1996). Compost has many more qualities that can attribute to the economics and agronomics of any crop to utilize these products. These other qualities can be factored into the economical equation. There has been limited research on the utilization of compost for the express purpose of nutrient assimilation, uptake and utilization. Furthermore, there has been even less in the area of turf research. If enough usable information is compiled in this area, a blank may be filled in pertaining to the environmental/economical equation (Wong, 1997; Agnew, 1992; Landschoot, 1995).
Although the number of studies has been limited, some have been promising. One study utilized an in-field incubation of the soil amended with 1% or 2% Composted Green yard and landscape Waste (w/w), (CGW), and showed no net nitrogen release over four months (Hartz et al., 1996). As Landschoot states, studies with biosolids have concluded that about 10% of the total nitrogen in the composted biosolids is available in the first growing season (Landschoot, 1995).

Hartz also set up a field trial with bell peppers (Capsicum annum L.). Fruit yield was increased by soil amended with CGW (17 or 34 t/ha\(^{-1}\)) under low N fertilizer regimes (168 kg. /ha\(^{-1}\)), but was unaffected where sufficient N fertilizer (280 kg. /ha\(^{-1}\)) was applied. The utilization of CGW blended with perlite performed better than the same 50/50 blend of perlite and peat, with tomatoes (Lycopersicon esculentum Mill.) and marigolds (Tagetes erecta L.) being the indicator crops. Plants under the varying fertigation regimes (constant feed of N at 0, 50, or 100 mg./L\(^{-1}\) as 15:13:12) of CGW were equivalent or superior to peat in plant growth. CGW did contribute to crop macronutrient nutrition by making macronutrient content of the plants higher than the plants grown on peat, but the highest fertigation rate was required for optimum growth of the plants. In conclusion of the study, Hartz stated that it is difficult to quantify the economic benefit of soil amended with CGW. In field trial, high rates of application (2 to 4 times rates common in the vegetable industry) gave a marginal yield increase under a limited N application regime; with a sufficient fertilizer program, no crop production benefits were observed (Hartz, 1996).

A study was initiated to investigate the value of natural organic fertilizers as a nitrogen source for plant growth. He utilized seven products for comparison against urea
and a non-fertilized control plot. The organic products were Milorganite 6-2-0, an activated sewage sludge; Ringer Greens Restore 6-1-3, a hydrolyzed poultry feather meal with wheat germ, soybean meal, and corn fermented solubles; Ringer Turf Restore 10-2-6, a hydrolyzed poultry feather meal with blood meal, wheat germ, and bone meal; Sustane 5-2-4, an anaerobically composted turkey litter (fine and medium grade); ISU expa 10-10-0; a corn gluten meal, local source; ISU expb 5-3-5, a composted chicken litter, local source (Agnew, 1992).

These organic products were applied at the rate of 454 g. N/92.9meters$^2$ in May, June, August and September, totaling 1.816 kg. /92.9meters$^2$/year to a ($Poa pratensis$) Kentucky bluegrass turf. His objectives were to take visual readings and weight of clippings received from each of the different plots. In all visual readings except the October and August evaluation the urea out performed all other applications. In all but two readings, May and August, the control also performed below all other applications. All of the other experimental products performed at or above the minimum acceptable level of turf visual quality except the Sustane. The Sustane product fell below the acceptable level of turf appearance in the months of July, August, September and October. There was also a reduction of clippings across the panel of organic products when compared to the urea treated plots (Agnew, 1992).

A study at the University of Hawaii at Mano was conducted utilizing composted poultry manure as a fertilizer. This pot study was conducted with corn being the indicator crop. There were two composts utilized in this experiment: one product was composted poultry manure and the other was a poultry manure/wood chip mixture. These were applied to 2kg. of Leilehua soil at 6 rates (0, 10, 20, 40, 50, 100 tons
compost/ha). The experimental plants were grown for 4 weeks, and then the tissues produced were dried and weighed for evaluation. The dry matter of the plants increased with increasing rates of compost to a maximum of 50 tons compost/ha with manure/woodchips and 45-50 tons/ha with manure. These yields were significantly higher (P<0.05) than yields with 20 tons/ha or less (Silva et al., 1996).

There was another study conducted at the University of Hawaii to evaluate the best means of supplementing organic compost with inorganic fertilizers using bermudagrass (*Cynodon dactylon*) as the indicator crop of one mixture and corn for the other. They supplemented poultry organic waste with inorganic nutrients (N, P, K) to produce a nutrient ratio of 16-6-8. There was also a second formulation of organic and inorganic fertilizers that reached a ratio of 10-10-10. The augmented compost fertilizer treatments were compared to commercial fertilizers with the same ratios, Turf Supreme 16-6-8 and Ortho 10-10-10. Both the mixes and the straight inorganic fertilizers were applied at 5 rates (0, 100, 200, 400, 800,) kg N/ha. The bermudagrass indicator was cut every two weeks over a 63-day period. These tissues were dried and the weights recorded. The corn was grown for 4 weeks and the harvested and dried to be weighed. The results were significantly higher for the bermudagrass treated with the mixture of organics and inorganic than with the inorganic alone. The maximum dry matter productions for both the maize and the bermudagrass occurred at 800 kg N/ha with all the materials (Silva, et al., 1996).

A study by Reicher and Hardebeck utilized Maple (*Acer sp.*) leaf litter to apply to a perennial ryegrass (*Lolium perene*) stand of turf. These leaves were mowed with a mulching mower and directly incorporated into the existing turf. The leaves were applied
in this manner at the rates of 0, 1780, and 3560 kg/ha in a single application. During the first year, the plots were further broken down to receive three different nitrogen rates, 0, .908, and 1.816 kg N/92.9 m²/year. The third year this procedure was adjusted to rates of .908, 1.816, and 2.724 kg N/92.9 m²/year. These plots were evaluated by clipping weights, visual quality, and nutrient concentrations. They concluded that for four of the six-year study, the leaves had no negative affect on visual qualities, turf growth by clipping weight measurements, or nutrient availability (Reicher, 1998).

Most of these studies show promise, but some of the studies, such as the Hartz paper, show no production benefits were observed. However, this study was over only one four-month growing season, and only utilized an annual crop. Many of these studies showed that the ideal situation for observing and comparing the utilization of organic amendments would be over an extended period of time and after many applications. Many of these studies show some positive differences in the second year and some in the following years. These studies show promise for the use of many organic amendments for many reasons, including the utilization of organic waste that would go into a landfill into useable materials that curb the need for use of fungicides, as well as decreasing water and fertilizer expenditures in future applications.
MATERIALS AND METHODS

This study was conducted at the Charles Taylor Turf Research Station on the Western Kentucky University Research Farm. The lay out was a complete random block designee. The main plots of 274.5cm by 157.5cm are composed of three cultivars of bentgrass “Pencross,” “G-2,” “L-93,” which are creeping bentgrasses, and one cultivar of dryland bentgrass (Agrostis casteleng) “Exeter.” Each main plot was subdivided into three different applications of test products, IBDU fertilizer, Sawdust/manure compost, and leaf compost. Each of the main plots was replicated four times resulting in sixteen main plots and forty-eight subplots.

These grasses were established October of 1997 on the native soil of Pembroke silt loam with 2-6% slopes. Cultural practices performed on the test site prior to the initiation of the test consisted of mowing, watering, spraying and fertilization. The plots were maintained at 1.27 cm, which is a popular fairway height. The plots were mown once a week and twice when needed. The watering was used liberally three to five times a week at 30 minutes to 1 hour per station and as needed to prevent stress. Spraying was used during peek times of potential Pythium and Dollar Spot pressure. Ethazole trade name Koban was used twice each year to prevent pythium. Azoxystrobin methyl (E)-2-{2-[6-(2-cyanophenoxy) pyrimidin-4 yloxy]-3-methoxycrylate trade name Heritage was used at the rate of 5.675 grams/92.9m$^2$ to prevent broad spectrum fungal disease. One application of chlorothalonil (tetrachloroisophthalonitrile) trade name Daconil Ultrex at the curative rate of 170.25 grams /92.9m$^2$ and one spray at the preventive rate of 85.125 grams/92.9m$^2$ were utilized once each year to prevent other diseases. The fertilization
was limited to .681 kilograms of actual N per applications, from a 31% Isobutyl diurea (IBDU) source, combined for the growing seasons of 97 and 98.
A. Maintenance of Plots

Cultural Practices after the initiation of the study consisted of mowing, spraying, watering, aerification, and fertilization. The mowing of the plots remained the same as previous once per week and twice when needed. Retaining the 1.27 centimeter height.

Watering was limited to once to twice per week at 45 minute to 75 minute applications per station dependent upon weather conditions. This practice was followed to evoke mild stress for variability of the plots. The summer of 1999 ended in a near record drought, which helped further the stress.

Spraying was still limited to peak potential pressure for Pythium and curative for dollar spot. The dollar spot pressure resulted in two curative applications for the growing season of 1999. The dollar spot activity was to be one objective of the experiment, but the pressure was too great and a fungicide treatment had to be applied halfway through the growing season. The total sprays that resulted for 1999 were one curative and two preventive sprays. One application of chlorothalonil (tetrachloroisophthalonitrile) trade name Daconil Ultrex at the curative rate of 170.25 grams/92.9 m² and one spray at the preventive rate of 85.125 grams/1000 were utilized. The other preventive spray was of azoxystrobin: methyl (E)-2-{2-[6-(2-cyanophenoxy) pyrimidin-4 yloxy] pheny}'-3-methoxyacrylate, trade name Heritage at the rate of 5.675 grams/92.9 m².

In the growing season of 2000, four sprays of Daconil Ultrex were utilized to curb the formation of dollar spot. There was also a need for weed control after the first year. Thin turf cover resulted in the emergence of broad leaf winter annuals, and post emergent control was used. Two applications of Dimethylamin salt of 2,4 Dichlorophenoxyacetic...
acid, Dimethylamin salt of 2-(2 methyl-4-chlorophenoxo) propionic acid, Dimethylamine salt of dicamba (3,6-dichloro-o-anisic acid) trade name Trimec Classic applied at the rate of 29.57ml./92.9m² were used ten days apart to alleviate the problem of broad leaf weeds.

Aerifications were made prior to the spring and fall applications of materials. This procedure was executed by using a GA 30 that was equipped with 1.59 cm wide X 7.62 cm. long, hollow tines that were set on 6.35cm centers. After the aerification took place the cores were removed by a snow shovel to avoid receiving cross contamination of turf cultivars. The fertilization of the plots by the experimental units of compost was then applied to the freshly aerified and cleaned plots. This practice took place in April, June, and September.
B. Treatment Preparation

There were three different materials utilized: IBDU (31% N), 1-2 year old composted leaves, and 1-2 year old sawdust/manure compost. The IBDU is a commercially available slow release organic fertilizer and is a commonly used product on golf courses.

The leaf compost was obtained from the Western Kentucky University composting facility. The leaves consist of urban leaf litter from the city of Bowling Green. The leaves were composted for 1-2 years in windrows that were mixed and turned as needed to maintain acceptable internal temperatures of the compost. After collecting the leaves at the compost site they were taken to the lab and dried to 20-30% moisture. Some were dried in a drying cabinet that was set at 37.78°C. Frequent turning of the compost was required to speed drying. Dry materials were also obtained by placing them into cardboard boxes on the lab benches and frequently turning them; and some leaf compost was dry directly from the site. The materials then had to be further processed to obtain uniformity and finer texture for ease of application. This product was then run through a destroyer and processed to the needed consistency. Twenty to thirty percent proved to be the best moisture percentage to keep down dust and to keep material flowing through the machine. Eighty to ninety percent of this resulted material would pass through a No. 10 mesh screen. The material was chemically analyzed and was found to have a 1.15% nitrogen content.

The sawdust/manure compost was a 50-50% blend by volume of hardwood sawdust and dairy cattle manure. This compost was also 1-2 years old and is composted in the same manner as the leaf compost. The percent moisture was approximately the
same, and the same machine was used to process both materials. The main differences between the two materials are first the percent nitrogen and secondly particle size. The sawdust/manure compost had a lower nitrogen percentage of 0.95%. The particle size resulted in only 75-85% passing through the No. 10 mesh screen. Particles of limestone were detected in the compost, which accounted for some of the difference. Most likely those stones came from the cleaning of the dairy floor.

The two composts were prepared in small batches, and each batch received the same procedure for determining the moisture percentage. The materials were usually mixed in batches that filled a 208-liter drum. The drum was filled and rolled around, similar to the way a cement mixer mixes cement. This procedure was followed to achieve an even distribution of moisture throughout the barrel, because each of the smaller units of processed material had different readings. After rolling the sealed barrel around, several samples were taken from different depths of the barrel. The barrel was then sealed to maintain the same moisture level as the representative samples. These samples were to be checked for total percent moisture by completely drying them to 0% moisture by a furnace. Then the percent moisture is calculated and subtracted from the total wet weight leaving the totally dry weight. The correct amount of product was then calculated to apply the rate of 227g/92.9m² of nitrogen to each 15 square foot plot and bagged up into plastic bags. This procedure was performed on the two composts but was not performed on the IBDU fertilizer because it has a guaranteed analysis on the bag.
C. Applications of Materials

The applications of the test products occurred in April, June and September. Prior to the April and September applications the plots were aerified. The aerification had two purposes: first, to get oxygen to the roots but mostly to help incorporate the materials into the soil profile. After aerification, the cores were removed by snow shovels to reduce the possibility of cross contamination. Then the test products were applied by hand. This method proved to be the best method to spread approximately 454 grams of compost and 11 grams of IBDU products over 1.39 meters$^2$ sub plot. The application of the compost will result in complete coverage of the leaf blades on the plot. Furthering the application by hand brushing the plot incorporated the materials into the aerification holes and the stand of grass. The IBDU fertilizer had to be mixed with sand to help ensure an even application to the plot. Mixing the IBDU with moist sand proved to be the best way to keep the fertilizer distributed evenly throughout the sand.

After each material was applied to its respective location, the water was turned on to help further incorporate the materials and to activate the fertilizer. The plots were not mowed for one week to insure that none of the materials were picked up or moved to other plots. After one week and two waterings, most of the materials were firmly implanted into their proper places and the normal maintenance routines resumed.
Illustration 1. Aerified plots that have been treated with sawdust/manure compost next to the IBDU treated plot on the left.
Illustration 2. All plots post treatment
D. Sample Collection

One month after the materials were applied tissue samples were taken. The samples were taken in May, July and October. In each sampling both leaf tissue and thatch samples were taken. The leaf tissue was sheared off via hand shears, taking a representative sample of the entire plot that totaled 3-5 grams of wet material and placed into a labeled envelope. The thatch samples were taken via a soil probe. The probe was placed into the ground less than an inch and pulled out a core. The core then had the leaf tissue trimmed off and the soil was pulled off leaving only the thatch sample. The sample was shaken to remove excess soil leaving behind thatch (thatch being defined as soil, roots, senesced leaves and other organic matter waiting to be broken down) then placed into a labeled envelope.

The samples were then dried via a drying cabinet that was maintained at 37.8 °C for approximately one week. The samples could then be processed in a Wiley mill. The samples were run through the Wiley mill to enable the sample to be analyzed. After running the sample through the Wiley mill the end result of the sample was fine enough to pass through the No. 40 mesh screen. In between each grinding the mill is cleaned via a vacuum and a brush when needed to get the entire previous sample out of the machine. After the materials have been processed, they are placed back into the drying cabinet until needed for analysis.
E. Analysis

The final process is analyzing the samples for nitrogen content. This process was achieved by utilizing a Leco 2000 CHN analyzer, which measures the amount of carbon, hydrogen, and nitrogen in each sample run through it. This analyzer accomplishes its purpose by analyzing the gasses released after a sample is burned inside its burn chamber. The analyzer requires only .08 grams for each run to give an accurate reading. Prior to each analyzing period the analyzer is recalibrated. If more than 50 samples are run in one analyzing period, the analyzer must also be recalibrated. After every ten samples are run, there will be a duplicate sample run to check make sure that the analyzer is still reading accurately. If the machine has different readings for the same sample the analyzer will be recalibrated. The Leco 2000 CHN measures down to the .0001% level. For this reason all samples were rounded to the nearest two places. At that precise level, the samples had inconsistent results, usually less than one hundredth of a percent.

Visual readings were also utilized in the overall analysis of the three test products. Visual readings were taken weekly or biweekly from March till November using a scale of 1-9, based on color and cover. The number 6 represents acceptable turf for a reference point. The number one represents turf that is either entirely brown or completely gone.

After all data were collected for both percent nitrogen and visual readings the data were analyzed by using Statistical Analytical System to compare differences of treatment and cultivars at the .05 level.
RESULTS AND DISCUSSION

The results from this study indicate that bentgrass turf utilized for fairway use in south central Kentucky will be a challenge. Its use will be further complicated if less than optimal conditions are present. There was one cultivar, Exeter, that proved to be less susceptible to the regional conditions under a lower maintenance situation. Although this grass is not the finest texture or the densest grass in the study, it did maintain a better stand under the extremes subjected to this field of bentgrasses. This cultivar could be useful in developing a more heat tolerant bentgrass cultivar that is more suitable to the south, especially in a fairway setting.

The second year, table 5 b, the variety L-93 performed statistically better than the other varieties in the majority of the sample periods. The second year was lower over all for all varieties. There are many reasons that could have removed Exeter from the top position, including the accumulation of only 1.362 kg N/92.9m² over the two year period of the study and no nitrogen the two years prior to the study. The lack of water was also a major factor. Both years of the study were during extreme drought conditions for the area. Furthermore, supplemental irrigation was limited to minimal applications. These variables provided extreme conditions for the evaluation of cultivars that could survive the conditions of the area. The cultivars that survived well could represent a genetically stronger bentgrass plant that could possibly be further developed as a more heat tolerant bentgrass. The two cultivars that showed a slight statistical edge in this area were Exeter and L-93.

The results for the nitrogen analysis of the plant tissues that were being affected by the type of fertilizer showed that the IBDU held the highest rankings all six times and
shared the number one ranking only two other times. One of the times was with leaf and
the other being with both leaf and sawdust/manure compost. The results for the thatch
samples concluded that all had no statistical difference between them.

In this study there was a more positive retention of N in the leaf portion of the
plant based on the type of fertilizer material. Chemically there was a statistical difference
for the IBDU fertilizer. The visuals of this portion of the study yielded little to no
difference.

Here is an explanation of the data retrieved for the 1999 figure 1a. Figure 1a
represents the differences, or lack there of, for the nitrogen percentage content in the leaf
material of the turf grasses. All of the treatments were combined to compare the four
cultivars: Exeter, Penncross, L-93, and G-2. There was no statistical difference among
the four cultivars that were tested except in the month of October. The average range for
the percentages of N contained in the bentgrass leaf material ranged from 2.34% to
3.98% among the four cultivars.

Figure 1b follows rankings close to the previous year with only minor exceptions
in the nitrogen percentage differences. In May the two cultivars Penncross and L-93
were significantly lower than the other two. Then in July Penncross was lower and the
overall percents were slightly lower.

Figure 2a illustrates the percentages of N concentration in the thatch portions of
the different cultivars. The only statistical differences associated with each sample
periods were for Exeter in the May sample and all four cultivars being separated in July
except for the AB ranking of Penncross. July is noticeably different from these other two
periods. This variance could be the result of many possibilities of May and October due
to the lower percent of nitrogen concentration. One possibility could be that some of the
reserves in the thatch might have been used in a sink source relationship to feed the plant
during this near dormant period. This near dormant period was caused by the extreme
summer conditions, i.e. heat and lack of water, which caused much stress to these plants.
There was also the possibility of nitrogen immobilization that could also explain the
decline or lack on nitrogen being present.

Figure 2b has some of the same characteristics as the figure 2a but there is a little
more separation in the month of May, which could be due to time. The July sample
period only has three rankings where Fig. 2a has four rankings in July. The Month of
July also has a much higher average again which could be due to the possibility of
nitrogen immobilization.

Figure 3a illustrates the N percentages contained within the leaf comparing the
treatments, IBDU, composted leaf litter, and composted sawdust/manure compost,
against each other. There was statistical difference within each of the sample periods.
During the first year the IBDU had the highest percents for all three of the sample
periods, but leaf compost was equivalent during the October sampling period. The leaf
compost had lower percentages during the May and July sample periods than in the
month of October, providing statistically higher results. The sawdust/manure had second
place rankings for all sample dates. The percentages of all three of the treatments rose
throughout the year, this increase is most likely due to the plant’s build up of
carbohydrates before the winter season.

Figure 3b illustrates almost the same results as the previous year with only one
exception. The sawdust/manure product performed statically the same as the other two
products in October. This may be explained by mineralization on nitrogen that was in the compost material.

Figure 4a illustrates the differences in the nitrogen percentages contained within the thatch of the turf based upon treatment. Most all sample dates were statistically the same and had only one variation for the month of July. During the month of July the readings were almost half that of the other months possibly due to the excessive heat combined with a deficiency in water that could have lead to nitrogen immobilization.

Figure 4b illustrates some similar characteristics of being ranked the same as the previous year with the exception that the month of July’s nitrogen percentages is higher than the other months and starts to decline in the fall sample date. The reason could be due to a larger cycle that involves mineralization and immobilization along with tolerances of cultivars to the conditions presented to the study units in this experiment.

Figure 5a illustrates the statistical difference between cultivars. These readings were for the seven months after the initiation of this study. The first two months of this study Penncross was ranked at the top. After the first two months adverse conditions, disease, high temperatures, and drought reduced performance. The year 1999 was a severe drought year, which continued into 2000. The summer temperatures were also near record highs. These conditions placed G-2 in the bottom of the rankings due to being a higher maintenance turf. Penncross stayed in the top half of the rankings because it could withstand the conditions. The cultivar Exeter stayed in the top of the rankings throughout the summer utilizing minimal inputs to create a better low maintenance turf.

The readings for 2000 are illustrated in figure 5b. The 2000 readings rebounded from the end of the 1999 season and continued to rebound until July. July is the month
when summer’s stressful conditions makes its impression on the results by lowering the entire field. This year’s data was not as low due to reduced disease pressure and a more normal summer temperature. G-2 drops to the bottom of the statistical rankings except for the month of August where it was equal to all others. The cultivar L-93 was at the top with 6 “A” place rankings out of 7 total. This ranking was different from the first year where Exeter had 5 “A” place rankings out of 7 total. This difference could be due to 2 years of the study that only utilized 1.362 kilo/92.9m². Both Figures 6a & 6b state that for both years virtually all visual observations of the fertility treatments faired equal and had only minor statistical differences throughout this study.
CONCLUSION

The conclusion for the first portion of the study reveals that the utilization of composted leaves and composted sawdust/manure for the sole fertilizer source of a bentgrass fairway turf is not superior to the use of an IBDU fertilizer. There are benefits for the use of composted organic materials, but for the criteria set in this study there was no significant difference. Further studies should be conducted on finding combinations of compost and fertilizer that will reach the optimum levels that both products have to offer.

The conclusion for the cultivar performance portion of this study showed there may be potential for bentgrass fairways in the southern transition zone if conditions do not become too severe— for example, severe drought and low nitrogen levels. There were two cultivars that showed both promise and potential for further development. Exeter was one of the cultivars that exhibited its tolerance for extreme summer heat and drought. This cultivar performed the best during the first year under severe drought conditions. This cultivar lacks in visual requirements for bentgrass in this area due to its thin wiry appearance that is not acceptable for fine turf. The cultivar L-93 demonstrated recuperative abilities during the second year of the study, leading to the conclusion that L-93 can survive the persistent adverse conditions of low nitrogen levels and low water inputs. These attributes would be an excellent addition to a new more heat tolerant cultivar of bentgrass.
Table 1a. Percentage of nitrogen in leaf tissue for 1999 sample dates.

<table>
<thead>
<tr>
<th></th>
<th>MAY</th>
<th>JULY</th>
<th>OCTOBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exeter</td>
<td>2.34a*</td>
<td>2.88a</td>
<td>2.94b</td>
</tr>
<tr>
<td>Penncross</td>
<td>2.59a</td>
<td>2.58a</td>
<td>3.57a</td>
</tr>
<tr>
<td>L-93</td>
<td>2.43a</td>
<td>2.64a</td>
<td>3.74a</td>
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<tr>
<td>G-2</td>
<td>2.45a</td>
<td>2.54a</td>
<td>3.98a</td>
</tr>
</tbody>
</table>

*Values in a column followed by the same letters are not different at the .05 level of probability based on the Duncan’s multiple range test.
Percentage of nitrogen in leaf tissues for 1999

Figure 2
Table 1b. Percentage of nitrogen in leaf tissue for 2000 sample dated.

<table>
<thead>
<tr>
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<th>OCTOBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exeter</td>
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<td>3.04a</td>
</tr>
<tr>
<td>Penncross</td>
<td>1.83b</td>
<td>2.77a</td>
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</tr>
<tr>
<td>L-93</td>
<td>1.86b</td>
<td>2.4a</td>
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<td>G-2</td>
<td>2.23a</td>
<td>2.73a</td>
<td>3.08a</td>
</tr>
</tbody>
</table>

*Values in a column followed by the same letters are not different at the .05 level of probability based on the Duncan’s multiple range test.
Percentage of nitrogen in leaf tissue for the sample periods of 2000

Figure 3
Table 2a. The Percentage of nitrogen in the thatch tissue for sample dated in 1999

<table>
<thead>
<tr>
<th></th>
<th>MAY</th>
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<th>OCTOBER</th>
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<tr>
<td>Exeter</td>
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<td>Penncross</td>
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<td>.41ab</td>
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<td>.66a</td>
<td>.33b</td>
<td>.55a</td>
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<td>G-2</td>
<td>.87a</td>
<td>.48a</td>
<td>.74a</td>
</tr>
</tbody>
</table>

*Values in a column followed by the same letters are not different at the .05 level of probability based on the Duncan's multiple range test.
Percentage of nitrogen in thatch for sample dates in 1999

Figure 4
Table 2b. The percentage of nitrogen in the thatch tissue for sample dated in 2000.

<table>
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<tr>
<th></th>
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<th>OCTOBER</th>
</tr>
</thead>
<tbody>
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<tr>
<td>Penncross</td>
<td>.66b</td>
<td>.70b</td>
<td>.53a</td>
</tr>
<tr>
<td>L-93</td>
<td>.55b</td>
<td>.81ab</td>
<td>.58a</td>
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<tr>
<td>G-2</td>
<td>.87a</td>
<td>.92a</td>
<td>.67a</td>
</tr>
</tbody>
</table>

*Values in a column followed by the same letters are not different at the .05 level of probability based on the Duncan’s multiple range test.
Percent of nitrogen in thatch for sample dates of 2000

Figure 5
Table 3a. The percentage of nitrogen in the leaf tissue based on treatment during 1999

<table>
<thead>
<tr>
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<th>OCTOBER</th>
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</thead>
<tbody>
<tr>
<td>IBDU</td>
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<td>Leaf Compost</td>
<td>2.27b</td>
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<td>3.61a</td>
</tr>
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<td>Sawdust/Manure Co</td>
<td>2.41b</td>
<td>2.44b</td>
<td>3.20b</td>
</tr>
</tbody>
</table>

*Values in a column followed by the same letters are not different at the .05 level of probability based on the Duncan’s multiple range test.
Figure 6

Percentage of nitrogen in leaf tissue during sample dates of 1999
Table 3b. The percentage of nitrogen in the leaf material based on treatment during 2000

<table>
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<th>JULY</th>
<th>OCTOBER</th>
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</thead>
<tbody>
<tr>
<td>IBDU</td>
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<td>3.17a</td>
</tr>
<tr>
<td>Leaf Compost</td>
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<td>2.39b</td>
<td>3.16a</td>
</tr>
<tr>
<td>Sawdust/Manure Co</td>
<td>1.86b</td>
<td>2.41b</td>
<td>3.37a</td>
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*Values in a column followed by the same letters are not different at the .05 level of probability based on the Duncan's multiple range test.
Percentage of nitrogen in leaf tissue based on treatments during sample periods during 2000

Figure 7
Table 4a. The percentage of nitrogen in the thatch based on treatment for 1999

<table>
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<tr>
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<th>OCTOBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBDU</td>
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<tr>
<td>Leaf Compost</td>
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<td>.62a</td>
<td></td>
</tr>
<tr>
<td>Sawdust/Manure Co</td>
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<td>.30a</td>
<td>.67a</td>
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</tr>
</tbody>
</table>

*Values in a column followed by the same letters are not different at the .05 level of probability based on the Duncan’s multiple range test.
The percentage of nitrogen in thatch based on treatment for sample periods of 1999

Figure 8
Table 4b. The percentage of nitrogen in the thatch based on treatment for 2000

<table>
<thead>
<tr>
<th></th>
<th>MAY</th>
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<th>OCTOBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBDU</td>
<td>.65a*</td>
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<td>.53a</td>
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<tr>
<td>Leaf Compost</td>
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<td>.80a</td>
<td>.54a</td>
</tr>
<tr>
<td>Sawdust/Manure Co</td>
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<td>.76a</td>
<td>.48a</td>
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*Values in a column followed by the same letters are not different at the .05 level of probability based on the Duncan's multiple range test.
Percentage of nitrogen in thatch based on treatment for sample dates of 2000

Figure 9
Table 5a. Visual performance of cultivar by month for the 1999 growing season.

<table>
<thead>
<tr>
<th></th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
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</thead>
<tbody>
<tr>
<td>Exeter</td>
<td>6.17c*</td>
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<td>4.53a</td>
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<tr>
<td>Penncross</td>
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<td>6.27ab</td>
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<td>1.72b</td>
<td>1.88b</td>
</tr>
<tr>
<td>L-93</td>
<td>6.44b</td>
<td>6.02b</td>
<td>3.64c</td>
<td>1.83bc</td>
<td>1.29b</td>
<td>1.44c</td>
<td>1.54bc</td>
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<tr>
<td>G-2</td>
<td>6.39b</td>
<td>6.54a</td>
<td>3.72bc</td>
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<td>1.37b</td>
<td>1.26d</td>
<td>1.25c</td>
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</table>

*Values in a column followed by the same letters are not different at the .05 level of probability based on the Duncan's multiple range test.*
Visual readings of cultivars for 1999

Figure 10

<table>
<thead>
<tr>
<th>2000</th>
<th>April</th>
<th>May</th>
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<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exeter</td>
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<td>2.0b</td>
<td>2.97b</td>
</tr>
<tr>
<td>L-93</td>
<td>2.88b</td>
<td>3.8a</td>
<td>4.18a</td>
<td>3.69a</td>
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<td>3.49a</td>
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<tr>
<td>G-2</td>
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*Values in a column followed by the same letters are not different at the .05 level of probability based on the Duncan’s multiple range test.
Visual performance of cultivars for 2000

Exeter
Penncross
L-93
G-2

Figure 11

<table>
<thead>
<tr>
<th></th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBDU</td>
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<td>6.16a</td>
<td>4.43a</td>
<td>2.58a</td>
<td>2.13a</td>
<td>1.86b</td>
<td>1.9a</td>
</tr>
<tr>
<td>Leaf compost</td>
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<td>3.88a</td>
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<td>2.19a</td>
<td>2.06a</td>
<td>2.09a</td>
</tr>
<tr>
<td>Sawdust/manure</td>
<td>6.43a</td>
<td>5.86a</td>
<td>3.9a</td>
<td>2.63a</td>
<td>2.27a</td>
<td>2.02a</td>
<td>2.09a</td>
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</table>

*Values in a column followed by the same letters are not different at the .05 level of probability based on the Duncan’s multiple range test.
Visual performance of treatments for 1999

Figure 12
Table 6b. Visual performance of fertilizer treatment by month for the 2000 growing season.

<table>
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<tr>
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<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBDU</td>
<td>2.69b*</td>
<td>3.34a</td>
<td>3.8a</td>
<td>3.58a</td>
<td>3.52a</td>
<td>2.28a</td>
<td>3.18a</td>
</tr>
<tr>
<td>Leaf compost</td>
<td>2.92a</td>
<td>3.38a</td>
<td>3.72a</td>
<td>2.89b</td>
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<td>2.47a</td>
<td>3.28a</td>
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<tr>
<td>Sawdust/manure</td>
<td>2.9a</td>
<td>3.41a</td>
<td>3.78a</td>
<td>3.13b</td>
<td>3.48a</td>
<td>2.42a</td>
<td>3.15a</td>
</tr>
</tbody>
</table>

*Values in a column followed by the same letters are not different at the .05 level of probability based on the Duncan’s multiple range test.
Visual performance of treatment for 2000

Figure 13
References


Waters (and Related Questions). USDA, Washington, D.C.
