Evaluation of Manufactured Organic Soil Amendments for Consumer Use

by

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A thesis submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Master of Science

Auburn, Alabama
August 6, 2011

Keywords: landscape, organic fertilizer, organic compost, turf maintenance, vegetables

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Abstract

Commercial substrate blending companies and fertilizer companies are now producing manufactured substrates and fertilizers that are marketed as "organic." Homeowners care about the aesthetics of their landscape, thus the consumers buy fertilizers to achieve a greener lawn. However, most current products are market driven with little research to document product effectiveness. Physical properties play a major role in the character and effectiveness of a fertilizer. Properties that have agronomic consequences are particle size distribution and the rate of disintegration in water of a fertilizer, which is the first step towards solubility. Particle size distribution also plays a factor in the ability to spread effectively and ease of coverage of a specific area. In experiment one, a set of test sieves where used to determine the particle size distribution of two manufactured organic fertilizers, Secret Garden pelletized (SGP) and Secret Garden Granular (SGG) products, and also Scott's Organic Choice Lawn Fertilizer (SOC). SGP had the largest portion of large particles of the three fertilizers evaluated with ~50% being caught in a No. 6 (3.36 mm) sieve, SOC had a more heterogeneous mixture, and SGG had the smallest particles of the three fertilizers. In the 60-second disintegration in water test experiment, SOC had significantly heavier un-disintegrated dry weights than the other two fertilizers suggesting that SOC dissolves less rapidly. For the second part of the experiment, the 300-second portion, there were different results. SGG (14.14g) and SOC (10.85g) had the heaviest un-disintegrated dry weight remaining of the three fertilizers. There were no differences in the 480 second test using an altered procedure to obtain comparable rates. A second study evaluated the effects on

the aesthetics of Meyer Zoysia turf following applications of four commercially available fertilizers. At 2 weeks after application (WAA), SGG (8.25 lbs N/ 5000 ft^2), SGP (8.25 lbs N/ 5000 ft^2), SGP (6.6 lbs N/5000 ft^2), Sodium Nitrate (3.26 lbs N/ 5000 ft^2), and Urea-ammonium nitrate (3.12 lbs N/ 5000 ft^2) had the highest visual ratings. Still at 4 WAA, the same treatments had the highest visual ratings (VR). At 6 WAA SGP (8.25 lbs N/ 5000 ft^2) outperformed SGP (3.3 lbs N/ 5000 ft^2), Urea-ammonium nitrate (3.12 lbs N/ 5000 ft^2), and SGG treatments 3.3 lbs N/ 5000 ft^2 and 4.125 lbs N/ 5000 ft^2. All of the remaining treatments were similar to SGP (8.25 lbs N/ 5000 ft^2). At 10 WAA no VR differences were observed among treatments. Initial readings on leaf chlorophyll content (LCC) were taken at 4 WAA. The following treatments were rated the highest at the initial readings: SGG (4.125 lbs N/5000 ft^2), SGG (6.6 lbs N/5000 ft^2), SGG (8.25 lbs N/5000 ft^2), SGP (3.3 lbs N/5000 ft^2), SGP (6.6 lbs N/5000 ft^2), SGP (8.25 lbs N/5000 ft^2), SOC (4.001 lbs N/ 5000 ft^2), SOC (8.002 lbs N/ 5000 ft^2), and ammonium nitrate. At 6 WAA there was little difference among the treatments. The only difference was SGP (4.25 lbs N/ 5000 ft^2) outperforming and SOC (4.001 lbs N/ 5000 ft^2). By 10 WAA all treatments were statistical similar in LCC. Warm season grasses have a dormant period during winter and when cold enough there is no green tissue visible. In the spring when temperatures begin to rise the turfgrass begins to put out new shoots, stolons and rhizomes. This time period has become to be known as spring green-up and is very important in landscape and turfgrass management. Fertilizer and other lawn amendments are commonly applied to promote the new growth once the temperatures rise. The demand for organic products has caused manufacturers to begin producing “green” amendment products for spring green-up use. In a third study, effects on the spring green-up of turf following applications of four commercially available fertilizers were evaluated. At 2 WAA SGG (8.25 lbs N/ 5000 ft^2) VR was significantly higher than several treatments including the non-fertilized control, however SGP (6.6 lbs N/ 5000 ft^2), SGP (4.125 lbs N/5000 ft^2), SGG (6.6 lbs N/ 5000 ft^2), SGP (4.125 lbs N/5000 ft^2), and SOC (8.002 lbs N/ 5000 ft^2), VR were statistically similar. By 10 and 11 WAA all fertilized treatments were similar. An additional study evaluated the growth of two vegetables, squash and cabbage, grown in different depths of manufactured organic compost. Home vegetable gardening has begun to regain popularity over the last few years. With the "green" movement in full swing home gardeners are always looking for new ideas to become "organic" or sustainable in the way they produce vegetables. Organic soilless substrates in raised beds may be a way for homeowners to achieve their vision of sustainability. There were no significant differences in yield among the treatments of different depths of compost and the non-amended earthen bed control for the entirety of the study.

Acknowledgments

The author would like start by thanking Dr. Jeff L. Sibley for his guidance and his example of selfless leadership, work ethic, and his perspective shown while in pursuit of this degree. A meeting with Dr. Sibley at Ruby Tuesday's in the fall of 2006 is where the author became convinced to give Horticulture a try because of Dr. Sibley's love and passion for the green industry. The author would also like to thank Dr. Wheeler G. Foshee, III and Dr. Donald J. Eakes for their guidance and teaching while in pursuit of this degree. Jeremy M. Pickens, this was not possible without your help, ideas, guidance, and the many helpful tools found in your truck. Seriously, your explanation of the research process and your example of work ethic were invaluable to the author during the last year.

Deep appreciation is also in order for the authors' parents, Daryl and Angela Thaxton, and family. The love and support shown my whole life have shaped the author completely. Dad your example as a father is as good as any earthly example can be. Mom you have given the author an awesome example of a wife, which the author used while finding a wife of his own.

Katherine, without your support and confidence in the author, the degree could not even be attempted. Thank you for your selflessness the last year, the author will do everything in his power to make it worth it. Love you!

Last but not least the author would like to thank Jesus Christ. The relationship with Jesus is and will always direct and define the author's life and decisions. May the author seek You the rest of his life.

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List of Abbreviations

N	Nitrogen
P	Phosphorus
K	Potassium
SS	Sewage Sludge
BYM	Barnyard Manure
PL	Poultry Litter
FM	Feather Meal
MBM	Meat and Bone Meal
LM	Liquid Manures
PR	Plant Residues
SGG	Secret Garden Granular
SGP	Secret Garden Pelletized
SOC	Scott's Organic Choice Lawn Food
CPL	Composted Poultry Litter
DR	Disintegration Rates
VR	Visual Ratings
LCC	Leaf Chlorophyll Content
WAA	Week after application
FW	Fresh Weights

DW	Dry Weights
EC	Electrical Conductivity
DAP	Days After Planting
IDFC	International Fertilizer Development Center

CHAPTER I

Introduction and Literature Review

The demand for environmentally friendly products has contributed greatly to an increased awareness about the "greenness" of manufactured products. Consumers, investors, environmental interest groups, and government are applying pressure to the manufacturers and others to provide green materials. A "Green" focus has changed the priorities of many companies. Initially, governments were reluctant to go "green" (Roarty, 1997). Governments have since taken a proactive role in a more sustainable community and country. In the United States, State lawmakers are writing legislation to regulate fertilization practices. In Washington state, politicians and industry are at odds because of regulations being passed by the government. Industry leaders accuse the politicians of writing laws without actual science backing them (White, 2011). Over time, manufacturers and landscape management firms are starting to incorporate environmentally friendly business criteria into their marketing and maintenance plans. As a part of these plans, manufacturers have begun to create "green" products, which are generally marketed as organic, along with other characteristics such as: natural, non-toxic, sustainable, and recyclable (Roarty, 1997). In 2010, the organic industry was valued at $29 billion dollars with the organic supplements sector valued at $681 million dollars, which was a 7.4% increase from 2009 (Kuack, 2011).

Synthetic or chemical based fertilizers began to replace all-organic fertilizers in agriculture when first introduced in the 1960s. Many nations have relied upon chemical fertilizers to keep up with production demand for agricultural products. Ignoring the importance of organic amendments and stabilization in the soil, some agriculture lands have declined, along with a decline in productivity of the soil. The 1970s energy crisis led to the first major exponential increase in the cost of traditional chemical fertilizers, which led to a renewed interest in alternative forms of plant nutrition (Parr et al., 1986). Subsequently increased cost of natural gas in the 1990's along with increased use of synthetic fertilizers in the world has led to a second surge in chemical fertilizer costs. Urea, the primary solid form of nitrogen used in fertilization, prices increased 127% during a seven year period of 2000 to 2007 (Wen-yuan, 2007).

Now with emphasis on organic production, many different sources of organic nutrition have been sought out by developing countries as well as industrialized nations. Organic wastes include: animal manures, crop residues, sewage sludge, food processing wastes, industrial organic wastes, logging manufacturing wastes, municipal refuse, and many other types of organic substances (Parr et al., 1986).

Barnyard manures (BYM) have commonly been used as fertilizers in the past, or as means to add organic matter (Harp et al., 2008). BYM are usually solid excreta from farmyard animals that are, to a certain degree, dry in composition. BYM are usually comprised of bedding materials and spilled feed along with the animal waste (Wood, 2008).

Poultry litter (PL) has become a BYM of choice for an organic fertilizer, in concentrated form or as a compost (Harp et al., 2008). PL, also referred to as broiler litter, is a mixture of manure, waste feed, feathers, wood shavings, and other bedding residues (Brink et al., 2004). The poultry production industry has welcomed the use of PL as a fertilizer because of waste management problems the industry has encountered (Moore Jr. et al., 1995). Generally, PL has a fertilizer grade of 3N-1.3P-1.66K, but it is often difficult to know how much N is available to the plant upon application. Two thirds of the N source is usually in an unusable state right away and can be lost through volatilization if not incorporated into the soil. Through mineralization, the N becomes available over time, acting as a slow release type of fertilizer. Generally, about 70% of the N applied to crops from PL will be available to plants by the end of the first year after application. The high variability of PL may make it necessary to attain a lab analysis in order to determine the appropriate amounts of PL for application (Mitchell and Donald, 1995). The time of application of PL is also important because of the relatively quick mineralization of N. The timing of PL application for crops to be able to utilize N is also of vital importance. Studies show that for best utilization of PL nitrogen, spring application is recommended (Thomsen, 2004). The rates are often applied heavier than recommended because of the loss of N (Brink et al., 2004).

Feather meal (FM) is a processed form of poultry feathers with other byproducts of the poultry rendering process. FM has been used as a source of animal nutrition previously but is often thought to be unsatisfactory because of the animal's poor digestion of the material. FM has about 15% non-soluble N, which must be broken down by microbial organisms. This characteristic has placed FM into an organic slow release type of fertilizer category (Hadas and Kautsky, 1994).

Sewage sludge (SS), commonly referred to as biosolids, has been studied as another organic fertilizer. SS has been shown to provide adequate amounts of N and P, although N plant use is much more proficient than P plant use, but the success of SS as a fertilizer is very dependent upon the process used to treat the sewage and the soil to which it is applied. Soil incorporation of SS pre-plant has been used, but often with unpredictable success (Correa, 2004). Studies show SS to be extremely variable leading to problems determining the amount of organic N compared to inorganic N (Smith et al., 1998), along with substantial concerns of the content of heavy metals present in SS (Wood, 2008). According to the USDA, SS is not an acceptable form of organic fertilizers (OF) for agricultural use (Reisig and Bladon, 2011).

Meat and Bone Meal (MBM) has typically been used as an animal feed. However, in 2000 concerns stemming from out breaks of mad cow disease and the possible negative effect of MBM as a feed material on the animals caused MBM to be banned as an animal feed in Europe. Because of the high nitrogen content in MBM (about 8%), studies have been conducted to evaluate the effectiveness of MBM as a source of plant nutrition. As much as 80% of the N content in MBM is used in the first growing season. MBM also has marked amounts of calcium, containing around 10% in most cases. Despite MBM containing close to 5% of P, the plant use efficiency of P is only about 50% of that applied. As with many other OF, there is a question about the residual amounts of P left in the soil (Jeng et al., 2006).

Liquid manures, or other types of slurry (LM), are another option that are sometimes used by dairy farmers to fertilize their grazing grass. LM is derived from animal wastes that are dropped on solid surfaces and washed into drains to store in lagoons or holding tanks. Liquid manures commonly have moderate amounts of N-P-K because of the low concentration of dry matter within the solution (Wood, 2008). Slurry has been commonly applied on the surface of the grasslands in the past, but has come to be considered an unacceptable form of application because of the volatilization of ammonia or loss of N. Other application methods have been adopted to reduce this setback, such as soil slitting or injecting (Schils and Kok, 2003).

Plant residues (PR) found in materials such as green manures, or cover crops have also been used at times as a source of crop fertilization. Plants used are often selected for their ability to render inorganic N available to the crop. Different plant residues present vastly different nutrient compositions. The availability of N from PR largely depends on the C:N ratio of the applied PR (Hadas et al., 2004) Green manures are applied by growing a crop in the off-season of the main crop to add nutrients and organic matter to the soil (Wood, 2008).

There are many other types of OF such as guano, neem, and vermicompost. In addition, there are multiple potential types of OF that could be utilized with more research.

There are many benefits to OF, but fertilizers are usually judged for their usefulness by their N-P-K content. OF generally has smaller amounts of N-P-K than traditional chemical fertilizers. However this does not mean that OF are not as valuable or even as useful as chemical fertilizers, because there are other very important factors to consider when selecting fertilizers. OF may be valuable because of other factors that may influence crop yield or aesthetics. Micronutrients and organic matter introduced into the soil may be just as valuable as the macronutrient, N-P-K (Parr et al., 1986). Studies have shown that organic "wastes" positively affect the soil's composition of organic matter, CEC, and structural improvement (Aggelides and Londra, 2000).

Also, OF are considered to have a substantial effect in agricultural sustainability. Granted, there can be a concern of over application of manures and OF to the land. While using chemical fertilizers, there is a genuine concern of depleting the resources around us. To maintain sustainability, nutrients must cycle from the soil, to the crop, to the animal or human, and back to the soils in form of manures, which maintains the soil as a valuable asset to produce crops for many generations (Schroder, 2004). In the age of environmental concern, this has brought the aforementioned manures and organically based fertilizers to the forefront of many research projects in agriculture.

Organic fertilizers typically have a slow release tendency resulting from the mineralization process of N. The availability of N to the plant is contingent on the amounts of mineral N or organic N within the fertilizer, as well as other factors. Mineralized N will be available to the plant, with as much as 60% used in the first year the OF is applied. Organic N will slowly add to the N levels in the soil for use in the future (Gutser et al., 2005), which can be a positive quality for OF, and can be utilized to provide nutrition through the growing season.

Potential problems exist with OF, as with other fertilizers. Some concerns are possibilities of a build up of excessive trace elements within the soil with potential leaching to water sources, or these non-biodegradable additions to the soil will be taken up by the plants ultimately affecting humans and animals by crop consumption. There are valid concerns for accumulation of trace element after years of application of organic manure products (Gupta and Charles, 1999). However, studies have shown that OF contribute similar amounts of trace metals as chemical fertilizers despite the lower amounts of inert metals in chemical fertilizers (Frost and Ketchum Jr., 2000). Other studies have shown a significant difference in the accumulation of As, Cd, Cu, and Mn in soils with organic manures applied compared to soils with no manures applied.

An additional concern often examined with OF manures is the excess P incorporated into the soil when OF are applied heavily from demanding N rates. When an excessive amount of P is applied to a field, the concern is that it will affect water quality from P by water surface runoff. When applying organic manures, P is typically over applied by three or four times the amount that can be utilized by crops, in an attempt to meet crop N requirements. An extreme amount of

P in water sources can render water sources un-recreational, un-farmable (fisheries), and unusable for industry and municipalities. It is recognized that most manure application operations have over applied for many years until not long ago (McFarland and Hauck, 2004).

Handling and application of organic wastes has become problematic to farmers and other handlers. Composting is generally the primary way to cope with this problem. Raw organic wastes typically have large bulk and odor involved, while composting will help eliminate the odor and reduce the bulk dramatically (Adediran et al., 2003). Composting breaks down the raw organic material to nutrients in a decomposed state, allowing organic wastes to complement each other. When one organic material is lacking in N but has a favorable C:N ratio, another waste with high amounts of N can be composted with it to provide a suitable compost and fertilizer (Harp et al., 2008; Parr et al., 1986). Other circumstances have to be considered while composting. Type, time, and materials to be composted must be examined while producing compost. There are several different ways to compost, with duration for each process type being one of the main factors impacting the resulting compost (Buchanan and Gliessman, 1991). Composting solves many problems related to raw wastes being exposed to humans and animals through crops (Lopez-Mosquera et al., 2007). Composting municipal solid waste has been studied as an amendment for okra and watermelon production. With increasing rates of municipal solid waste incorporation to the soil, there was an increase in yield for both okra and watermelon though watermelon was not significantly different. Increased yields where likely because of improved soil physical and chemical properties (Lu et al., 2008).

Another option considered while dealing with raw organic wastes is heat drying and pelletizing. Heat drying and pelletizing could improve storability and reduce or remove the odors associated with raw organic wastes, thus improving consumer acceptability and improve the value raw organic wastes as a OF. Studies have shown pelletizing could reduce some aspects of variability in OF, but also increase variability of N characteristics, likely due to the volatilization of ammonium in high temperatures reached while drying. Heat drying and pelletizing creates a superior product compared to raw organics when considering storing, transportation, and application (Lopez-Mosquera et al., 2007).

Physical properties also play a part in application and effectiveness of fertilizers. Physical properties such as particle size distribution have an influence on storage and handling, blending, spreading, along with an agronomic effect. The agronomic effect comes from the rate of disintegration of the particle, which is correlated to the rate of N availability (Hofstee, 1992). The rate of disintegration in water can also have an impact on N availability to the plant (Rutland, 1986).

OF may be able to produce similar results to traditional synthetic fertilizers. The results of OF should come with a different approach than chemical fertilizers. Chemical fertilizers generally have a predictable effect on plants while OF have many factors influencing their effectiveness. Temperature and microbial activity may cause a great deal of variability on OF (Jones, 2011).

Very little research has been done on the use of OF or organic composts in the urban landscape. Manufacturers of fertilizers are expected to produce more organic compost and fertilizers in the years ahead as a result of the general public's recognition of conservation of the environment. Limited information about the use of OF in the landscape exists, excluding a study on the effect of OF on bedding plants. One study evaluated the use of organic fertilizers, composed of recycled newspaper and PL effects on the bedding plants within an urban landscape (Altland et al., 2002).

Another study analyzed the effects of composted poultry litter (CPL) as a fertilizer for landscape use (Marble, 2009). In this study the results showed that plants fertilized with CPL produced quality as good or better than those fertilized with synthetic fertilizers. The study also showed that CPL could be applied at much higher N rates than that of synthetic fertilizers with very little environmental impacts. The study concluded that CPL could supplement synthetic fertilizers for bedding plants (Marble, 2009). Another study was done comparing CPL as turf fertilizer on 'Meyer' Zoysiagrass (*Zoysia japonica* 'Meyer' (Z-52)) to synthetic controlled release fertilizer. The study was conducted on newly laid sod by means of incorporation to the soil, in full sun, and under overhead irrigation. The results showed that there were minor differences between treatments of CPL and synthetic controlled release fertilizers, but all fertilizer treatments resulted in acceptable green turfgrass. The study showed that CPL could be an acceptable form of fertilization for newly sodded turf (Marble, 2009).

Research has been conducted on the effect of composted municipal solid waste as a soil amendment for growth of vegetables. Crop yield and heavy metal concentration within the eatable parts of the vegetable were studied. It was found that the compost had positive effects on yield while the compost did not cause increased amounts of heavy metals in eatable parts of the vegetables that would be detrimental if consumed (Lu et al., 2008).

A different study investigated the effects of compost type on invasion of common bermudagrass in landscape beds. CPL proved to have an immediate effect on the rate of invasion of common bermudagrass, while other various composts had slower effects on the rate of invasion (Harp et al., 2008).

Even with the research previously mentioned there is still little known about manufactured OF and composts use in the landscape and for vegetable gardening. If the best organic composts and fertilizers methods for use and rates can be identified, it will give manufactures positive information to produce with and will give the consumers information to use while purchasing or composting at home. The purpose of this research will be to evaluate some commercially available organic fertilizers for use in the urban landscape, along with evaluation of manufactured organic soil amendments in production of vegetables.

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CHAPTER II

Particle Size Distribution and Disintegration in Water of Three Manufactured Organic Fertilizers

Significance to the Industry

Physical properties play a major role in the character and effectiveness of a fertilizer. Two properties of a fertilizer that have agronomic consequences are particle size distribution and the rate of disintegration in water. Particle size distribution is also a factor in the ability to spread a material effectively and ease of coverage of a specific area. Commercial substrate blending companies and fertilizer companies are now producing manufactured substrates and fertilizers that are marketed as "organic." These fertilizers have very little research applied to their marketing plans and need to be held to the same standard as other traditional products. In experiment 1, a set of test sieves were used to determine the particle size distribution of the following three manufactured organic fertilizers: Secret Garden pelletized (SGP), Secret Garden Granular (SGG), and Scott's Organic Choice Lawn Fertilizer (SOC). SGP had the largest portion of large particles of the three fertilizers evaluated with ~50% being caught in a No. 6 (3.36 mm) sieve, SOC had a more heterogeneous mixture, and SGG had the smallest particles of the three fertilizers. In experiment 2, results showed that SGG had the highest disintegration rate (DR) in the 60 second test, however the dry weight left un-disintegrated was not different from SGG. SGP had the highest DR in the 300 second test. There were no differences in the 480 second test using an altered procedure to obtain comparable rates.

Introduction

Handling and application of organic wastes has become problematic to farmers and other handlers. Composting is generally the primary way to cope with this problem. Raw organic wastes typically have large bulk and odor involved, while composting will help eliminate the odor and reduce the bulk dramatically (Adediran et al., 2003).

Composting breaks down the raw organic material to nutrients in a decomposed state, allowing organic wastes to complement each other. When one organic material is lacking in N but has a favorable C:N ratio, another waste with high amounts of N can be composted with it to provide a suitable compost and fertilizer (Harp et al., 2008). Other circumstances have to be considered while composting. Type, time, and materials to be composted must be examined while producing compost. There are several different ways to compost, with duration for each process type being one of the main factors impacting the resulting compost (Buchanan and Gliessman, 1991). Composting solves many problems related to raw wastes being exposed to humans and animals through crops.

Another option considered while dealing with raw organic wastes is heat drying and pelletizing. Heat drying and pelletizing can improve storability and reduce or remove the odors associated with raw organic wastes, thus improving consumer acceptability and improve the value raw organic wastes as a OF. Studies have shown pelletizing could reduce some aspects of variability in OF, but also increase variability of N characteristics, likely due to the volatilization of ammonium in high temperatures reached while drying. Heat drying and pelletizing creates a superior product compared to raw organics when considering storing, transportation, and application (Lopez-Mosquera et al., 2007).

Physical properties also play a part in application and effectiveness of fertilizers. Physical properties such as particle size distribution have an influence on storage and handling, blending, spreading, along with an agronomic effect. The agronomic effect comes from the rate of disintegration of the particle, which is correlated to the rate of N availability (Hofstee, 1992). The rate of disintegration in water can also have an impact on N availability to the plant (Rutland, 1986).

The demand for environmentally friendly products has contributed greatly to an increased awareness about the "greenness" of manufactured products. Consumers, investors, environmental interest groups, and government are applying pressure to the manufacturers and others to provide green materials. A "Green" focus has changed the priorities of many companies. Initially, governments were reluctant to go "green" (Roarty, 1997). Governments have since taken a proactive role in a more sustainable community and country. In the United States, State lawmakers are writing legislation to regulate fertilization practices. In Washington state politicians and industry are at odds because of regulations being passed by the government. Industry leaders accuse the politicians of writing laws without actual science backing them (White, 2011). Over time, manufacturers and landscape management firms are starting to incorporate environmentally friendly business criteria into their marketing and maintenance plans. As a part of these plans, manufacturers have begun to create "green" products, which are generally marketed as organic, along with other characteristics such as: natural, non-toxic, sustainable, and recyclable (Roarty, 1997). In 2010, the organic industry was valued at $29 billion dollars with the organic supplements sector valued at $681 million dollars, which was a 7.4% increase from 2009 (Kuack, 2011).

Synthetic or chemical based fertilizers began to replace all-organic fertilizers in agriculture when first introduced in the 1960s. Many nations have relied upon chemical fertilizers to keep up with production demand for agricultural products. Ignoring the importance of organic amendments and stabilization in the soil, some agriculture lands have declined, along with a decline in productivity of the soil. The 1970s energy crisis led to the first major exponential increase in the cost of traditional chemical fertilizers, which led to a renewed interest in alternative forms of plant nutrition (Parr et al., 1986). Subsequently increased cost of natural gas in the 1990's along with increased use of synthetic fertilizers in the world has led to a second surge in chemical fertilizer costs. Urea, the primary solid form of nitrogen used in fertilization, prices increased 127% during a seven year period of 2000 to 2007 (Marble, 2009).

Now with emphasis on organic production, many different sources of organic nutrition have been sought out by developing countries as well as industrialized nations. Organic wastes include: animal manures, crop residues, sewage sludge, food processing wastes, industrial organic wastes, logging manufacturing wastes, municipal refuse, and many other types of organic substances (Parr et al., 1986).

There are many benefits to OF, but fertilizers are usually judged for their usefulness by their N-P-K content. OF generally has smaller amounts of N-P-K than traditional chemical fertilizers. However this does not mean that OF are not as valuable or even as useful as chemical fertilizers, because there are other very important factors to consider when selecting fertilizers. OF may be valuable because of other factors that may influence crop yield or aesthetics. Micronutrients and organic matter introduced into the soil may be just as valuable as the macronutrient, N-P-K (Parr et al., 1986). Studies have shown that organic "wastes" positively affect the soil's composition of organic matter, CEC, and structural improvement (Aggelides and Londra, 2000).

Also, OF are considered to have a substantial effect in agricultural sustainability. Granted, there can be a concern of over application of manures and OF to the land. While using chemical fertilizers, there is a genuine concern of depleting the resources around us. To maintain sustainability, nutrients must cycle from the soil, to the crop, to the animal or human, and back to the soils in form of manures, which maintains the soil as a valuable asset to produce crops for many generations (Schroder, 2004). In the age of environmental concern, this has brought the aforementioned manures and organically based fertilizers to the forefront of many research projects in agriculture.

Organic fertilizers typically have a slow release tendency resulting from the mineralization process of N. The availability of N to the plant is contingent on the amounts of mineral N or organic N within the fertilizer, as well as other factors. Mineralized N will be available to the plant, with as much as 60% used in the first year the OF is applied. Organic N will slowly add to the N levels in the soil for use in the future (Gutser et al., 2005), which can be a positive quality for OF, and can be utilized to provide nutrition through the growing season.

Potential problems exist with OF, as with other fertilizers. Some concerns are possibilities of a build up of excessive trace elements within the soil with potential leaching to water sources, or these non-biodegradable additions to the soil will be taken up by the plants ultimately affecting humans and animals by crop consumption. There are valid concerns for accumulation of trace element after years of application of organic manure products (Gupta and Charles, 1999). However, studies have shown that OF contribute similar amounts of trace metals as chemical fertilizers despite the lower amounts of inert metals in chemical fertilizers (Frost and Ketchum Jr., 2000). Other studies have shown a significant difference in the accumulation of As, Cd, Cu, and Mn in soils with organic manures applied compared to soils with no manures applied.

An additional concern often examined with OF manures is the excess P incorporated into the soil when OF are applied heavily from demanding N rates. When an excessive amount of P is applied to a field, the concern is that it will affect water quality from P by water surface runoff. When applying organic manures, P is typically over applied by three or four times the amount that can be utilized by crops, in an attempt to meet crop N requirements. An extreme amount of P in water sources can render water sources un-recreational, un-farmable (fisheries), and unusable for industry and municipalities. It is recognized that most manure application operations have over applied for many years until not long ago (McFarland and Hauck, 2004).

OF may be able to produce similar results to traditional synthetic fertilizers. The results of OF should come with a different approach than chemical fertilizers. Chemical fertilizers generally have a predictable effect on plants while OF have many factors influencing their effectiveness. Temperature and microbial activity may cause a great deal of variability on OF (Jones, 2011).

The objective of this study was to compare the rate of disintegration in water and the particle size distribution of three manufactured organic fertilizers.

Materials and Methods

Particle Size Distribution: The experiment was conducted on July 29, 2010 to determine the particle size distribution of three different manufactured organic fertilizers: Secret Garden

Pelletized (SGP), Secret Garden Granular (SGG), and Scott's Organic Choice Lawn Food (SOC). The experiment was conducted in a lab at Paterson Greenhouse Complex at Auburn University. Three 150 g. samples were taken from the top, middle, and bottom of 30 lb bags of SGG and SGP, and a 29.1 lb bag of SOC. The sample was placed in a set of six sieves that were 1/2 in. (12.7 mm), 3/8 in. (9.51 mm), 1/4 in. (6.35 mm), No. 6 (3.36 mm), No. 8 (2.38 mm), and No. 10 (2.00 mm) and placed for three minutes in the Ro-Tap® sieve shaker (W.S. Tyler, Mentor, OH). The remaining fertilizer on each sieve was weighed and recorded. The fertilizer that passed through to the sieve pan was place onto a second six test sieves that were No. 14 (1.14 mm), No. 18, (1.00 mm) No. 35 (0.500 mm), No. 60 (0.250 mm), No. 140 (0.105 mm), No. 270 (0.053 mm) and again placed for three minutes in the Ro-Tap® sieve shaker (W.S. Tyler, Mentor, OH). The remaining fertilizer on each sieve was weighed and recorded. Percent on each sieve was calculated as followed:

$$\% \text{ on sieves} = \frac{\text{Weight on sieve, g}}{\text{Weight of sample, g}}$$

Disintegration in Water: Experiment 2 was conducted June 9, 2011 to determine the rate of disintegration in water of three manufactured organic fertilizers: Secret Garden Pelletized (SGP), Secret Garden Granular (SGG), and Scott's Organic Choice Lawn Food (SOC). The procedure used can be found in the Manual for Determining Physical Properties of Fertilizer by the International Fertilizer Development Center (IDFC) in Muscle Shoals, AL (Rutland, 1986). The experiment was conducted in a lab at Funchess Hall, Auburn University. Six 20g. samples of each fertilizer were prepared as described by the procedure using a Ro-Tap® sieve shaker (W.S. Tyler, Mentor, OH) and twelve test sieves that included: 1/2 in. (12.7 mm), 3/8 in. (9.51

mm), 1/4 in. (6.35 mm), No. 6, (3.36 mm) No. 8 (2.38 mm), and No. 10 (2.00 mm), No. 14 (1.14 mm), No. 18, (1.00 mm) No. 35 (0.500 mm), No. 60 (0.250 mm), No. 140 (0.105 mm), and No. 270 (0.053 mm). No. 230 (0.063 mm) was selected according to the procedure for SGG, and No. 35 was selected for SGP and SOC. The first three of the 20 g. samples were placed in the test sieves selected one at a time. The test sieve was submerged in a dishpan of water, maintained at 86°F, with 1.5 cm. above the sieve screen surface. The test sieve was attached to a Model DD Burrell Wrist-Action® shaker (Burrell Scientific, Pittsburgh, PA.). The Wrist-Action® shaker was adjusted to a 2.5 setting and turned on for 60 seconds. The sieve was immediately removed and placed in 105°C oven for 1 hr. The final three 20 g. samples were place in the water while attached to the Wrist-Action® shaker for 300 seconds and then immediately removed and placed in 105°C oven for 1 hr. Disintegration rates were determined according to the procedure as followed:

$$Dr = \frac{Sq - A}{Sq} \times 100$$

Where,

Dr = Disintegration rates

Sq = original subsample quantity (usually 20 g.)

A = amount of sample retained on screen, g.

Data for the disintegration in water was subjected to Tukey's Studentized Range Test (P = 0.05).

Disintegration in Water: Experiment 3 was conducted July 6, 2011 to determine comparable rates of disintegration in water of three manufactured organic fertilizers: Secret Garden Pelletized (SGP), Secret Garden Granular (SGG), and Scott's Organic Choice Lawn Food (SOC). The procedure was similar to experiment 2, outlined previously but altered to accommodate a fertilizer with small particles such as SGG. The experiment was conducted in a lab at Funchess Hall, Auburn University. Four 20g. samples of each fertilizer were prepared as described by the IDFC procedure in experiment 2 using a Ro-Tap® sieve shaker (W.S. Tyler, Mentor, OH) and twelve test sieves that included: 1/2 in. (12.7 mm), 3/8 in. (9.51 mm), 1/4 in. (6.35 mm), No. 6, (3.36 mm) No. 8 (2.38 mm), and No. 10 (2.00 mm), No. 14 (1.14 mm), No. 18, (1.00 mm) No. 35 (0.500 mm), No. 60 (0.250 mm), No. 140 (0.105 mm), and No. 270 (0.053 mm). No. 60 (0.250 mm) was selected to be a standard sieve for all fertilizers tested. The 20 g. samples were placed in the test sieve selected one at a time. The test sieve was submerged in a dishpan of water, maintained at 78-80°F, with 1.5 cm. above the sieve screen surface. The test sieve was attached to a Model DD Burrell Wrist-Action® shaker (Burrell Scientific, Pittsburgh, PA.). The Wrist-Action® shaker was adjusted to a 2.5 setting and turned on for 480 seconds. The sieve was immediately removed and placed in 105°C oven for 1 hr. Disintegration rates were determined according to the IDFC procedure as previously described.

Results and Discussion

Experiment 1: Particle size distribution showed Secret Garden Pelletized (SGP) had the largest particles of the three fertilizers evaluated with ~50% being caught in the No. 6 (3.36 mm) sieve. Scott's Organic Choice (SOC) had a more heterogeneous mixture with ~35% in a No. 8 (2.38 mm), ~20% in a No. 10 (2.00 mm), and ~25% in a No. 14 (1.14 mm). Secret Garden Granular (SGG) particle size distribution had the smallest particles of the three, with ~80% of particles falling through a No. 14 (1.14 mm) sieve screen (Table 1).

Experiment 2: The disintegration in water experiment showed the three fertilizers had different disintegration rates (DR) and significant differences in dry weights left un-disintegrated (Table

2). In the 60-second test portion of the experiment, Scott's Organic Choice Fertilizer (SOC) had significantly heavier un-disintegrated dry weights than the other two fertilizers suggesting that SOC dissolves less rapidly. Both Secret Garden Granular (SGG) and Secret Garden Pelletized (SGP) had similar results for un-disintegrated dry weights at 15.06g for SGG and 15.72g for SGP. For the second part of the experiment, the 300-second portion, there were different results. SGG (14.14g) and SOC (10.85g) had the heaviest un-disintegrated dry weight remaining of the three fertilizers. SGP (8.33g) also had similarities with SOC but had less un-disintegrated dry weights than SGG (Table 2).

Experiment 3: The altered disintegration in water experiment showed the three fertilizers had different disintegration rates (DR) but no differences in dry weights left un-disintegrated (Table 2). All three fertilizers were similar in un-disintegrated dry weights with SGG having 11.10g, SGP having 11.04g, and SOC having 11.94g.

Conclusion

SGG, SGP, and SOC have different particle size distributions and disintegration rates in water. Of the two pelletized products, SOC has a more heterogeneous mixture of particles in the fertilizer. SGP has the largest portion of large particles, and SGG has the largest portion of smaller particles throughout its mixture. With SGG and SGP having a labeled coverage rate of 5000 $ft.^2$ and SOC a labeled coverage rate of 4000 $ft.^2$, the different particle size distribution may play a factor in the effectiveness, coverage, and spreading of the materials. It may be difficult to get an even spread of SGP because of its larger particles. Therefore based on particle size distribution alone, the manufacturers of SGP may consider lowering the labeled coverage rate to 4000 $ft.^2$/30 lb. bag (3.3 lbs N/ 4000 $ft.^2$). Consumers might buy more of the product with the lower coverage rate, while manufacturers provide a better product in terms of spreadability and increased N/ft.

Results from the first disintegration in water experiment showed that both Secret Garden products had the fastest DR in the 60 second test of the fertilizers. In the 300 second test SGP and SOC had the highest DR. Disintegration is the first step towards solubility, thus DR is related to the availability of N to a plant. There are many other factors that would play a role in N availability, but when eliminating those and only considering DR; the Secret Garden products appeared to perform well. When changing the procedure to obtain more comparable results in experiment 3 there were no differences in dry weights left un-disintegrated. With the results seen from experiment 3 it is very difficult to determine the best of the three fertilizers. The DR were determined in a lab setting using agitation and submerged in water. When comparing fertilizers in this setting it may help show the ability of a fertilizer to disintegrate under normal conditions of irrigation or rainfall after application.

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Table 1. Particle size distribution[z] of Secret Garden Products and Scott's Organic Choice Lawn Fertilizer.

Secret Garden Pelletized 11-2-3 – 30 lb bag – Treats 5000 sq. ft.

	Sample:	**Sieve:** 1/2 in.	3/8 in.	1/4 in.	No. 6	No. 8	No. 10	No. 14	No. 18	No. 35	No. 60	No. 140	No. 270
Top	150.4 g.	0.0%[y]	0.0%	0.0%	53.7%	12.0%	4.1%	8.6%	4.7%	6.3%	4.5%	4.9%	0.7%
Middle	150.0 g.	0.0%	0.0%	0.0%	53.6%	10.6%	3.9%	7.9%	4.9%	7.3%	5.5%	5.0%	1.1%
Bottom	150.3 g.	0.0%	0.0%	0.0%	42.1%	9.7%	4.3%	10.3%	6.9%	10.2%	7.7%	6.2%	1.5%

Scott's Organic Choice Lawn Food 11-2-2 – 29.1 lb bag – Treats 4000 sq. ft.

	Sample:	**Sieve:** 1/2 in.	3/8 in.	1/4 in.	No. 6	No. 8	No. 10	No. 14	No. 18	No. 35	No. 60	No. 140	No. 270
Top	150.0 g.	0.0%	0.0%	0.0%	2.1%	37.8%	20.8%	23.5%	7.7%	5.1%	1.3%	1.7%	0.1%
Middle	150.1 g.	0.0%	0.0%	0.0%	2.9%	38.1%	20.2%	32.2%	7.5%	5.1%	0.9%	1.6%	0.3%
Bottom	150.1 g.	0.0%	0.0%	0.0%	1.4%	30.2%	19.7%	25.7%	11.1%	8.2%	1.4%	1.7%	0.1%

Secret Garden Granular 11-2-3 – 30 lb bag – Treats 5000 sq. ft.

	Sample:	**Sieve:** 1/2 in.	3/8 in.	1/4 in.	No. 6	No. 8	No. 10	No. 14	No. 18	No. 35	No. 60	No. 140	No. 270
Top	150.2 g.	0.0%	0.0%	0.0%	1.6%	4.8%	2.2%	6.8%	9.9%	29.9%	28.7%	14.8%	0.3%
Middle	150.5 g.	0.0%	0.0%	0.3%	0.7%	4.7%	0.7%	7.0%	10.2%	30.4%	28.1%	14.0%	0.3%
Bottom	150.1 g.	0.0%	0.0%	0.0%	2.5%	4.7%	2.5%	7.7%	11.1%	30.2%	26.9%	13.4%	0.2%

[z]Samples were placed in the test sieves and shaken for 6 minutes by a Ro-Tap® sieve shaker (W.S. Tyler, Mentor, OH).

[y]% on sieves = weight on sieve, g/weight of sample, g.

Table 2. Disinetgration rates[z] of manufactured organic fertilizers.

Fertilizer	IFDC Procedure[v]				Altered Procedure[u]	
	DR[y] at 60s	DR at 300s	Dry Weight[x] 60s[w]	Dry Weight 300s	DR at 480s	Dry Weight 480s
Secret Garden Granular	25.35%	31.05%			42.94%	
11-2-3	24.35%	29.05%	15.06b	14.14a	44.19%	11.10a
	24.40%	27.80%			42.55%	
					48.23%	
Secret Garden Pelletized	27.15%	71.75%			40.25%	
11-2-3	18.80%	52.90%	15.72b	8.33b	50.06%	11.04a
	18.50%	50.40%			44.79%	
					44.01%	
Scott's Organic Choice	12.00%	54.25%			47.88%	
11-2-2	13.15%	38.45%	17.47a	10.85ab	39.14%	11.94a
	12.75%	44.50%			45.63%	
					28.52%	

[z]Dr(%) = (Sq – A/Sq) x 100.

[y]Disinetigration rates.

[x]Dry weights is the remaining un-disintegrated particles, grams.

[w]Means within column followed by the same letter are not significantly different (Tukey's Studentized Range Test, $\alpha = 0.05$).

[v]Rutland, D.W. 1986. Disintegration rate in water (IFDC S-124), p. 77-79. In: E. D. Frederick and E. N. Roth (eds.). Manual for determining physical properties of fertilizer. Int. Fert. Dev. Ctr., Muscle Shoals, AL.

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CHAPTER III

Evaluation of Manufactured Organic Fertilizers on Zoysiagrass (*Zoysia japonica* 'Meyer')

Significance to the Industry

The demand for organic products has caused manufacturers to begin producing "green" products. Commercial substrate blending companies and fertilizer companies are now producing manufactured substrates and fertilizers that are marketed as "organic." Homeowners care about the aesthetics of their landscape, thus the consumers buy fertilizers to achieve a greener lawn. However, most current products are market driven with little research to document product effectiveness. This study evaluated the effects on the aesthetics of turf following applications of commercially available fertilizers. Secret Garden Organic fertilizer in granular form, at a rate of 681 g/100 ft^2 (8.25 lbs N/5000 ft^2) outperformed other commercially available organic fertilizers and Urea-ammonium nitrate 4 weeks after application (WAA) and 6 WAA. At 10 WAA there was no significant difference between all fertilizers evaluated.

Introduction

The demand for environmentally friendly products has contributed greatly to an increased awareness about the "greenness" of manufactured products. Consumers, investors, environmental interest groups, and government are applying pressure to the manufacturers and others to provide green materials. A "Green" focus has changed the priorities of many companies. Initially, governments were reluctant to go "green" (Roarty, 1997). Governments have since taken a proactive role in a more sustainable community and country. In the United States, State lawmakers are writing legislation to regulate fertilization practices. In Washington state politicians and industry are at odds because of regulations being passed by the government. Industry leaders accuse the politicians of writing laws without actual science backing them (White, 2011). Over time, more manufacturers and landscape management firms are starting to incorporate environmentally friendly business criteria into their marketing and maintenance plans. As a part of these plans, manufacturers have begun to create "green" products, which are generally marketed as organic, along with other characteristics such as: natural, non-toxic, sustainable, and recyclable (Roarty, 1997).

Synthetic or chemical based fertilizers began to replace all-organic fertilizers in agriculture when first introduced in the 1960s. Many nations have relied upon chemical fertilizers to keep up with production demand for agricultural products. Ignoring the importance of organic amendments and stabilization in the soil, some agriculture lands have declined, along with a decline in productivity of the soil. The 1970s energy crisis led to the first major exponential increase in the cost of traditional chemical fertilizers, which led to a renewed interest in alternative forms of plant nutrition. Subsequently increased cost of natural gas in the 1990's along with increased use of synthetic fertilizers in the world has led to a second surge in chemical fertilizer costs. Urea, the primary solid form of nitrogen used in fertilization, prices increased 127% during a seven year period of 2000 to 2007 (Marble, 2009).

Now with emphasis on organic production, many different sources of organic nutrition have been sought out by developing countries as well as industrialized nations. Organic wastes include: animal manures, crop residues, sewage sludge, food processing wastes, industrial organic wastes, logging manufacturing wastes, municipal refuse, and many other types of organic substances (Parr et al., 1986). In 2010, the organic industry was valued at $29 billion dollars with the organic supplements sector valued at $681 million dollars, which was a 7.4% increase from 2009 (Kuack, 2011).

Also, OF are considered to have a substantial effect in agricultural sustainability. Granted, there can be a concern of over application of manures and OF to the land. While using chemical fertilizers, there is a genuine concern of depleting the resources around us. To maintain sustainability, nutrients must cycle from the soil, to the crop, to the animal or human, and back to the soils in form of manures, which maintains the soil as a valuable asset to produce crops for many generations (Schroder, 2004). In the age of environmental concern, this has brought the aforementioned manures and organically based fertilizers to the forefront of many research projects in agriculture.

Handling and application of organic wastes has become problematic to farmers and other handlers. Composting is generally the primary way to cope with this problem. Raw organic wastes typically have large bulk and odor involved, while composting will help eliminate the odor and reduce the bulk dramatically (Adediran et al., 2003). Composting breaks down the raw organic material to nutrients in a decomposed state, allowing organic wastes to compliment each other. When one organic material is lacking in N but has a favorable C:N ratio, another waste with high amounts of N can be composted with it to provide a suitable compost and fertilizer (Harp et al., 2008). Other circumstances have to be considered while composting. Type, time, and materials to be composted must be examined while producing compost. There are several different ways to compost, with duration for each process type being one of the main factors impacting the resulting compost (Buchanan and Gliessman, 1991). Composting solves many problems related to raw wastes being exposed to humans and animals through crops. Another option considered while dealing with raw organic wastes is heat drying and pelletizing. Heat drying and pelletizing could improve storability and reduce or remove the odors associated with raw organic wastes, thus improving consumer acceptability and improve the value raw organic wastes as a OF. Studies have shown pelletizing could reduce some aspects of variability in OF, but also increase variability of N characteristics, likely due to the volatilization of ammonium in high temperatures reached while drying. Heat drying and pelletizing creates a superior product compared to raw organics when considering storing, transportation, and application (Lopez-Mosquera et al., 2007).

OF may be able to produce similar results to traditional synthetic fertilizers. The results of OF should come with a different approach than chemical fertilizers. Chemical fertilizers generally have a predictable effect on plants while OF have many factors influencing their effectiveness. Temperature and microbial activity may cause a great deal of variability on OF (Jones, 2011).

Research has be done studying the effects of composted poultry litter (CPL) as a fertilizer for landscape use (Marble, 2009). In this study the results showed that plants fertilized with CPL produced quality as good or better than those fertilized with synthetic fertilizers. The study also showed that CPL could be applied at much higher N rates than that of synthetic fertilizers with very little environmental impacts. The study concluded that CPL could supplement synthetic fertilizers for bedding plants (Marble, 2009). Another study was done comparing CPL as turf fertilizer on ‘Meyer’ Zoysiagrass (*Zoysia japonica* ‘Meyer’ (Z-52)) to synthetic controlled release fertilizer. The study was conducted on newly laid sod by means of incorporation to the soil, in full sun, and under overhead irrigation. The results showed that there were minor differences between treatments of CPL and synthetic controlled release fertilizers, but all fertilizer treatments resulted in acceptable green turfgrass. The study showed that CPL could be an acceptable form of fertilization for newly sodded turf (Marble, 2009).

The objective of this study was to compare aesthetic quality following application of manufactured organic fertilizers to an established Meyer Zoysia (*Zoysia japonica* 'Meyer') lawn.

Materials and Methods

On July 21, 2010, four manufactured organic fertilizers at different rates were compared to a standard synthetic fertilizer. The five manufactured fertilizers were Secret Garden pelletized (SGP) 11-2-3, Secret Garden granular (SGG) 11-2-3, Scott's Organic Choice Lawn Food (SOC) 11-2-2, Organic Sodium Nitrate 16-0-0, and Urea-ammonium nitrate fertilizer 32-0-0. SGG and SGP are made up of hydrolyzed feather meal, natural chilean nitrate, calcined bone meal, sulfate of potash, and molasses. SGG and SGP contain 1% nitrate N, 0.25% ammoniacal N, 0.75% water soluble N, and 9% water insoluble N. SOC is made up of hydrolyzed feather meal, meat meal, bone meal, blood meal, and sulfate of potash. SOC contains 0.11% ammoniacal N, 10% water insoluble N, and 0.89% water soluble N. The two Secret Garden products were applied at four different rates as follows: the labeled rate of 3.3 lbs of N/5000 ft^2 (272.4g of product/100 ft^2), 3.3 lbs of N/4000 ft^2 (340.5g of product/100 ft^2), 3.3 lbs of N/2500 ft^2 (544.8g of product/100 ft^2), and 3.3 lbs of N/2000 ft^2 (681.0g of product/100 ft^2). Scott's Organic Choice Lawn Food was applied at the following two rates: the labeled rate of 3.201 lbs of N/4000 ft^2 (330.3g of product/100 ft^2) and 3.201 lbs of N/2000 ft^2 (660.6g of product/100 ft^2). Urea-ammonium nitrate fertilizer was applied at one rate of 3.12 lbs of N/5000 ft^2 (90g of product/100 ft^2). Organic Sodium Nitrate fertilizer was applied at one rate of 3.26 lbs of N/5000 ft^2 (185g of product/100 ft^2). The plant material used was an established field of zoysiagrass (*Zoysia japonica* 'Meyer') among elm trees (*Ulmus* sp.), located on the campus of Auburn University at Agriculture Heritage Park on Samford Avenue (32°35'47.68"N x 85°29'36.86"W, USDA Hardiness Zone 8a). The Auburn University grounds crew mowed the zoysiagrass as needed to maintain the turf. The experiment was exposed to naturally occurring weather.

Initial visual ratings (VR) where taken August 4, 2010, 2 weeks after application (WAA). The VR where based on a 0-5 scale (0 = dead, 1 = no apparent change in aesthetics or greenness, 2 = a very mild change in greenness and not uniform, 3 = a mild change in greenness, 4 = a distinct difference in greenness, but not uniform, and 5 = a distinct difference in greenness throughout). VR were also taken at 4 WAA, 6 WAA, and 10 WAA.

A SPAD-502 meter (Minolta Camera Co., Ramsey, NJ) was used to determine leaf chlorophyll content on blades of zoysiagrass. Five samples where tested for chlorophyll content from each plot and averaged. The initial reading of chlorophyll content was at 4 WAA, and thereafter at 6 WAA and 10 WAA.

The study included 12 different treatments of fertilizer and one control treatment with no fertilizer applied. Plots were arranged in a randomized complete block design with five replications. Data collected were subjected to Duncan's Multiple Range Comparison test ($P = 0.05$).

Results and Discussion

Visual Ratings (VR). At 2 WAA, Secret Garden granular (SGG) (8.25 lbs N/ 5000 ft^2), Secret Garden pelletized (SGP) (8.25 lbs N/ 5000 ft^2), SGP (6.6 lbs N/5000 ft^2), Sodium Nitrate (3.26 lbs N/ 5000 ft^2), and Urea-ammonium nitrate (3.12 lbs N/ 5000 ft^2) had the highest visual ratings

(Table 3). Still at 4 WAA, the same treatments had the highest VR. At 6 WAA SGP (8.25 lbs N/ 5000 ft^2) outperformed SGP (3.3 lbs N/ 5000 ft^2), Urea-ammonium nitrate (3.12 lbs N/ 5000 ft^2), and SGG treatments 3.3 lbs N/ 5000 ft^2 and 4.125 lbs N/ 5000 ft^2. All of the remaining treatments were similar to SGP (8.25 lbs N/ 5000 ft^2). At 10 WAA no VR differences were observed among treatments (Table 3).

Comparing VR of all fertilizers at their own specific labeled rates revealed that there were little differences between SGG (3.3 lbs of N/5000 ft^2), SGP (3.3 lbs of N/5000 ft^2), and Scotts Organic Choice (SOC) (3.201 lbs of N/4000 ft^2). Initially, at 2 and 4 WAA the Sodium Nitrate and Urea-ammonium nitrate specific labeled rate applications outperformed the other three manufactured organic fertilizers at their specific labeled rates. Later in the study Sodium Nitrate and Urea-ammonium nitrate VR where statistically similar to the other fertilizers specific labeled rates applications. When comparing SGG (3.3 lbs of N/4000 ft^2) and SGP (3.3 lbs of N/4000 ft^2) to the SOC labeled rate (3.201 lbs of N/4000 ft^2), there were no differences in VR between all three treatments (Table 3).

Leaf Chlorophyll Content (LCC). Initial readings on LCC were taken at 4 WAA. The following treatments were rated the highest at the initial readings: SGG (4.125 lbs N/5000 ft^2), SGG (6.6 lbs N/5000 ft^2), SGG (8.25 lbs N/5000 ft^2), SGP (3.3 lbs N/5000 ft^2), SGP (6.6 lbs N/5000 ft^2), SGP (8.25 lbs N/5000 ft^2), SOC (4.001 lbs N/ 5000 ft^2), SOC (8.002 lbs N/ 5000 ft^2), and ammonium nitrate (Table 4). At 6 WAA there was little difference among the treatments. The only difference was SGP (4.25 lbs N/ 5000 ft^2) outperforming and SOC (4.001 lbs N/ 5000 ft^2). By 10 WAA all treatments were statistical similar in LCC.

Comparing LCC of all fertilizers at their own specific labeled rates there were no differences between SGG (3.3 lbs of N/5000 ft^2), SGP (3.3 lbs of N/5000 ft^2), and SOC (3.201 lbs of N/4000 ft^2). Throughout the study the labeled rates treatments were all similar in LCC. When comparing SGG (3.3 lbs of N/4000 ft^2) and SGP (3.3 lbs of N/4000 ft^2) products against the SOC labeled rate (3.201 lbs of N/4000 ft^2), there were statistical similarities for most of the study. SGP (3.3 lbs of N/4000 ft^2) did outperform SOC at its labeled rate (3.201 lbs of N/4000 ft^2) 6 WAA, however it was similar to SGG (3.3 lbs of N/4000 ft^2). By 10 WAA there were no differences among these treatments (Table 4).

Conclusion

In this study it was determined that SGG, SGP, SOC, and Sodium Nitrate are all viable candidates for landscape maintenance for Meyer Zoysia (*Zoysia japonica* 'Meyer') and perhaps other similar turfgrasses when compared to an industry mainstay Urea-ammonium nitrate. Determining the best fertilizer among SGG, SGP, and SOC is difficult when considering only VR and LCC. SGG and SGP carry recommended labeled coverage of 5000 ft^2 per 30 lb bag, where application of SOC is based on recommended 4000 ft^2 per 29.1 lb bag. Even with SOC higher rate of N/foot Secret Garden products were statistically similar in VR and LCC. Also price must be considered as well and Secret Garden Products \$6.02/ lb N, while is SOC is \$6.69/ lb N at lawn garden chain stores. SGG and SGP would be the better choice than SOC based on the results of this study when considering price per lb of N, VR, and LCC. Simplifying, SGG and SGP had higher labeled area of coverage than SOC and was still statistically similar in VR and LCC. The manufactured organic fertilizers tested could all be options for consumers when compared to other traditional synthetic fertilizers, and therefore may be a better option for consumers looking for a product marketed as more sustainable.

Regardless of product evaluated best results were attained in VR and LCC when doubling or over applying the fertilizers from the labeled rates. SGG (8.25 lbs of N/5000 ft^2) performed very well in VR compared to all treatments at 2 and 4 WAA, and at 6 WAA was similar to SGP (8.25 lbs of N/5000 ft^2) that had a very good VR that week. SGG (8.25 lbs of N/5000 ft^2) also performed well in LCC at 2 WAA though most treatments where similar. There were no perceived problems in plant health by VR and LCC while doubling the labeled rates of the manufactured organic fertilizers. Based on these results the manufacturers of these specific fertilizers may consider labeling an additional higher or double rate marketed to attain a greener lawn. This could be supplemental to the previous labeled rate and could have beneficial sales impact to the manufacturer if consumers use this rate over the other, thus buying more of the product.

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Table 3. Visual ratings[z] for Meyer Zoysia plot trial at 2, 4, 6, and 10 WAA[y].

Fertilizer	Rate (g /100ft.^{2})	Nitrogen lbs N/5000ft.^{2}	2WAA[x]	4WAA	6WAA	10WAA
Secret Garden Granular	272.4	3.3[w]	1.2f	1.2f	1.25bc	1.25a
11-3-3	340.5	4.125	2.2cdef	2.2cdef	1.25bc	1.0a
	544.8	6.6	2.4bcde	2.4cde	1.75abc	1.25a
	681	8.25	3.6a	3.6a	2.25ab	1.5a
Secret Garden Pelletized	272.4	3.3[w]	1.5ef	1.4ef	1.0c	1.0a
11-3-3	340.5	4.125	1.4ef	1.4ef	1.75abc	1.75a
	544.8	6.6	3.0abcd	3.0abcd	1.5abc	1.0a
	681	8.25	3.4ab	3.4ab	2.5a	1.25a
Scott's Organic Choice	330.3	4.001[w]	1.4ef	1.4ef	1.5abc	1.25a
11-2-3	660.6	8.002	2.0def	2.0edf	1.75abc	1.5a
Sodium Nitrate	185	3.26	3.2abc	3.2abc	1.5abc	1.25a
Urea-ammonium nitrate	90	3.12	2.8abcd	2.8abcd	1.25bc	1.5a
Non Fertilized Control	***	***	1.2f	1.2f	1.0c	1.25a

[z]Visual Ratings were based off the scale: 0 = dead, 1 = no apparent change in aesthetics or greenness, 2 = a very mild change greenness and not uniform, 3 = a mild change in greenness, 4 = a distinct difference in greenness, but not uniform, and 5 = a distinct difference in greenness throughout.

[y]Weeks after application.

[x]Means within column followed by the same letter are not significantly different (Duncan's Multiple Range Test, $\alpha = 0.05$).

[w]Labeled rates.

Table 4. Effects of manufactured organic fertilizers on leaf chlorophyll content[z] for Meyer Zoysia at 4, 6, and 10 WAA[y].

Treatment	Rate (g /100ft.^{2})	Nitrogen lbs N/5000ft.^{2}	4WAA[x]	6WAA	10WAA
Secret Garden Granular	272.4	3.3[w]	23.76bc	25.51ab	23.20a
11-2-3	340.5	4.125	23.96abc	25.39ab	28.02a
	544.8	6.6	25.77ab	25.83ab	28.47a
	681	8.25	27.12a	25.79ab	26.40a
Secret Garden Pelletized	272.4	3.3[w]	25.97ab	24.86ab	24.25a
11-2-3	340.5	4.125	23.53bc	27.13a	25.65a
	544.8	6.6	24.79ab	25.36ab	25.47a
	681	8.25	26.68ab	25.67ab	27.47a
Scott's Organic Choice	330.3	4.001[w]	25.38ab	24.03b	21.52a
11-2-2	660.6	8.002	23.94abc	26.88ab	26.72a
Sodium Nitrate	185	3.26	23.50bc	26.22ab	26.87a
Urea-Ammonium Nitrate	90	3.12	25.40ab	24.90ab	27.45a
Non Fertilized Control	***	***	21.38c	24.76ab	26.12a

[z]SPAD measured by Konika Minolta SPAD-502 Chlorophyll Meter, at respective weeks after application.

[y]Weeks after application.

[x]Means within column followed by the same letter are not significantly different (Duncan's Multiple Range Test, $\alpha = 0.05$).

[w]Labeled rates.

CHAPTER IV

Effect of Manufactured Organic Fertilizers on Hybrid Bermuda (*Cynodon dactylon* x *Cynodon transvaalensis*) for Spring Green-up

Significance to the Industry

Warm season grasses have a dormant period during winter and when cold enough there is no green tissue visible. In the spring when temperatures begin to rise the turfgrass begins to put out new shoots, stolons and rhizomes. This time period is known as spring green-up and is very important in landscape and turfgrass management. Fertilizer and other lawn amendments are commonly applied to promote the new growth once the temperatures rise. The demand for organic products has caused manufacturers to begin producing "green" amendment products for spring green-up use. The market driven "organic" products have very little research to back up their effectiveness. This study evaluated the effects on the spring green-up of turf following applications of commercially available fertilizers. Secret Garden Granular (SGG) fertilizer at a rate of 10.4g of product/1.53 ft^2 had the best results for the first 5 weeks after application (WAA). After 8 WAA Secret Garden Pelletized (SGP) at a rate of 10.4g of product/1.53 ft^2 and Scotts Organic Choice Lawn Food (SOC) at a rate of 10.1g of product/1.53 ft^2 were consistently the best treatments according to visual ratings (VR) with similarities to some other treatments. Even at 10 WAA SGG (10.4g of product/1.53 ft^2) had higher dry weights than other treatments.

Introduction

The demand for environmentally friendly products has contributed greatly to an increased awareness about the "greenness" of manufactured products. Consumers, investors, environmental interest groups, and government are applying pressure to the manufacturers and others to provide green materials. A "Green" focus has changed the priorities of many companies. Initially, governments were reluctant to go "green" (Roarty, 1997). Governments have since taken a proactive role in a more sustainable community and country. In the United States, State lawmakers are writing legislation to regulate fertilization practices. In Washington state politicians and industry are at odds because of regulations being passed by the government. Industry leaders accuse the politicians of writing laws without actual science backing them (White, 2011). Over time, more manufacturers and landscape management firms are starting to incorporate environmentally friendly business criteria into their marketing and maintenance plans. As a part of these plans, manufacturers have begun to create "green" products, which are generally marketed as organic, along with other characteristics such as: natural, non-toxic, sustainable, and recyclable (Roarty, 1997).

Synthetic or chemical based fertilizers began to replace all-organic fertilizers in agriculture when first introduced in the 1960s. Many nations have relied upon chemical fertilizers to keep up with production demand for agricultural products. Ignoring the importance of organic amendments and stabilization in the soil, some agriculture lands have declined, along with a decline in productivity of the soil. The 1970s energy crisis led to the first major exponential increase in the cost of traditional chemical fertilizers, which led to a renewed interest in alternative forms of plant nutrition. Subsequently increased cost of natural gas in the 1990's along with increased use of synthetic fertilizers in the world has led to a second surge in chemical fertilizer costs. Urea, the primary solid form of nitrogen used in fertilization, prices increased 127% during a seven year period of 2000 to 2007 (Marble, 2009).

Now with emphasis on organic production, many different sources of organic nutrition have been sought out by developing countries as well as industrialized nations. Organic wastes include: animal manures, crop residues, sewage sludge, food processing wastes, industrial organic wastes, logging manufacturing wastes, municipal refuse, and many other types of organic substances (Harp et al., 2008; Parr et al., 1986). In 2010, the organic industry was valued at $29 billion dollars with the organic supplements sector valued at $681 million dollars, which was a 7.4% increase from 2009 (Kuack, 2011).

Also, OF are considered to have a substantial effect in agricultural sustainability. Granted, there can be a concern of over application of manures and OF to the land. While using chemical fertilizers, there is a genuine concern of depleting the resources around us. To maintain sustainability, nutrients must cycle from the soil, to the crop, to the animal or human, and back to the soils in form of manures, which maintains the soil as a valuable asset to produce crops for many generations (Schroder, 2004). In the age of environmental concern, this has brought the aforementioned manures and organically based fertilizers to the forefront of many research projects in agriculture.

Handling and application of organic wastes has become problematic to farmers and other handlers. Composting is generally the primary way to cope with this problem. Raw organic wastes typically have large bulk and odor involved, while composting will help eliminate the odor and reduce the bulk dramatically (Adediran et al., 2003). Composting breaks down the raw organic material to nutrients in a decomposed state, allowing organic wastes to compliment each other. When one organic material is lacking in N but has a favorable C:N ratio, another waste with high amounts of N can be composted with it to provide a suitable compost and fertilizer (Harp et al., 2008; Parr et al., 1986). Other circumstances have to be considered while composting. Type, time, and materials to be composted must be examined while producing compost. There are several different ways to compost, with duration for each process type being one of the main factors impacting the resulting compost (Buchanan and Gliessman, 1991). Composting solves many problems related to raw wastes being exposed to humans and animals through crops. Another option considered while dealing with raw organic wastes is heat drying and pelletizing. Heat drying and pelletizing could improve storability and reduce or remove the odors associated with raw organic wastes, thus improving consumer acceptability and improve the value raw organic wastes as a OF. Studies have shown pelletizing could reduce some aspects of variability in OF, but also increase variability of N characteristics, likely due to the volatilization of ammonium in high temperatures reached while drying. Heat drying and pelletizing creates a superior product compared to raw organics when considering storing, transportation, and application (Lopez-Mosquera et al., 2007).

OF may be able to produce similar results to traditional synthetic fertilizers. The results of OF should come with a different approach than chemical fertilizers. Chemical fertilizers generally have a predictable effect on plants while OF have many factors influencing their effectiveness. Temperature and microbial activity may cause a great deal of variability on OF (Jones, 2011).

The objectives of this study were to compare the break of dormancy or initial spring "green-up" and aesthetic quality following application of manufactured organic fertilizers to Hybrid Bermuda (*Cynodon dactylon* x *Cynodon transvaalensis*) in a controlled environment.

Materials and Methods

The study was installed on February 18, 2011 comparing multiple rates of five manufactured fertilizers: one synthetic fertilizer, and four organic fertilizers. The five manufactured fertilizers were Secret Garden pelletized (SGP) 11-2-3, Secret Garden granular (SGG) 11-2-3, Scott's Organic Choice Lawn Food (SOC) 11-2-2, Organic Sodium Nitrate 16-0-0, and Urea-ammonium nitrate fertilizer 32-0-0. SGG and SGP are made up of hydrolyzed feather meal, natural chilean nitrate, calcined bone meal, sulfate of potash, and molasses. SGG and SGP contain 1% nitrate N, 0.25% ammoniacal N, 0.75% water soluble N, and 9% water insoluble N. SOC is made up of hydrolyzed feather meal, meat meal, bone meal, blood meal, and sulfate of potash. SOC contains 0.11% ammoniacal N, 10% water insoluble N, and 0.89% water soluble N. The two Secret Garden products were applied at four different rates as follows: the labeled rate of 3.3 lbs of N/5000 ft^2 (4.2g of product/1.53 ft^2), 3.3 lbs of N/4000 ft^2 (5.2g of product/1.53 ft^2), 3.3 lbs of N/2500 ft^2 (8.3g of product/1.53 ft^2), and 3.3 lbs of N/2000 ft^2 (10.4g of product/1.53 ft^2). Scott's Organic Choice Lawn Food was applied at the following two rates: the labeled rate of 3.201 lbs of N/4000 ft^2 (5.1g of product/1.53 ft^2) and 3.201 lbs of N/2000 ft^2 (10.1g of product/1.53 ft^2). Urea-ammonium nitrate fertilizer was applied at one rate of 3.12 lbs of N/5000 ft^2 (1.37g of product/1.53 ft^2). Organic Sodium Nitrate fertilizer was applied at one rate of 3.26 lbs of N/5000 ft^2 (2.83g of product/1.53 ft^2). The plant material used was 10.5 in. x 21 in., or 1.53 $ft.^2$, piece of Hybrid Bermuda sod (*Cynodon dactylon* x *Cynodon transvaalensis*). When the study was installed the Hybrid Bermuda was dormant. The study was conducted in a double-layer polyethylene-covered greenhouse with min/max temperatures set at 65ºF/85ºF located at Auburn University's Paterson Greenhouse Complex (32°35'47.38"N x 85°29'17.14"W, USDA Hardiness Zone 8a). All the sod pieces were hand-watered as needed.

Initial visual ratings (VR) where taken March 4, 2011, 2 weeks after application (WAA). The VR where based on a 0-5 scale (0 = more than 75% dormant or brown grass, 1 = more than 50% dormant or brown grass, 2 = green with brown or dead grass consistently mixed throughout, 3 = Thorough green, very little brown or dormant grass, 4 = full green, and 5 = full green with lush growth throughout). VR were also taken at 3 WAA, 4 WAA, 5 WAA, 8 WAA, 9 WAA, 10 WAA, and 11 WAA.

Fresh Weights (FW) was taken on March 25, 2011, 5 WAA. The yields were then placed in 175°F oven for three days and then weighed for dry weights (DW). DW were again collected at the termination of the study May 6, 2011.

A Soil Sample was collected initially before application February 18, 2011. The soil sample was analyzed for electrical conductivity (EC) and soluble salts. Soil samples were also collected at 4 WAA and 10 WAA. When putting together a soil sample, a small amount of soil was collected from each repetition and combined as one sample to form one composite sample per treatment to determine if EC and soluble salts values were related to VR, FW, and DW.

The study included 12 different treatments of fertilizer and one control treatment with no fertilizer applied. Plots were arranged in a randomized complete block design with seven replications. Data collected were subjected to Tukey's Studentized Range test ($P = 0.05$).

Results and Discussion

Visual Ratings (VR). At 2 WAA Secret Garden granular (SGG) (8.25 lbs N/ 5000 ft^2) VR was significantly higher than several treatments including the non-fertilized control, however Secret Garden pelletized (SGP) (6.6 lbs N/ 5000 ft^2), SGP (4.125 lbs N/5000 ft^2), SGG (6.6 lbs N/ 5000 ft^2), SGP (4.125 lbs N/5000 ft^2), and Scott's Organic Choice (SOC) (8.002 lbs N/ 5000 ft^2), VR were statistically similar (Table 5). Through 5 WAA Secret Garden granular (SGG) (8.25 lbs N/ 5000 ft^2) performed well in visual rating every week, though there were other treatments statistically similar each week. At 8 and 9 WAA SGP (8.25 lbs N/ 5000 ft^2) and SOC (8.002 lbs N/ 5000 ft^2) now had good VR outperforming the control, but all fertilized treatments were similar except SGG (3.33 lbs N/ 5000 ft^2) 9 WAA. 10 and 11 WAA all fertilized treatments were similar. SGP and SGP (8.25 lbs N/ 5000 ft^2) performed very good 10 WAA, while SGP (8.25 lbs N/ 5000 ft^2) and SGP (6.6 lbs N/ 5000 ft^2) VR performed were well at 11 WAA (Table 5).

Comparing VR of all fertilizers at their own specific labeled rates revealed no differences between SGG (3.3 lbs of N/5000 ft^2), SGP (3.3 lbs of N/5000 ft^2), Scotts Organic Choice (SOC) (4.001 lbs of N/5000 ft^2), Sodium Nitrate, and Urea-ammonium nitrate (Table 5). When comparing SGG (4.125 lbs of N/5000 ft^2) and SGP (4.125 lbs of N/5000 ft^2) to the SOC labeled rate (4.001 lbs of N/5000 ft^2), both SGG and SGP performed the same as SOC in VR through the entire duration of the study.

Fresh Weights (FW). FW were taken 5 WAA, treatment SGG (8.25 lbs N/ 5000 ft^2) had the highest weights and was significantly greater than all other treatments (Table 6). When comparing the FW of labeled rates of SGG (3.3 lbs of N/5000 ft^2), SGP (3.3 lbs of N/5000 ft^2), and Scotts Organic Choice (SOC) (3.201 lbs of N/4000 ft^2), SGG, SGP, and SOC had similarities in FW. SGG (3.3 lbs of N/4000 ft^2) and SGP (3.3 lbs of N/4000 ft^2) treatments where used to be compared to the SOC labeled rate (3.201 lbs of N/4000 ft^2), all three treatments performed the same in FW 5 WAA.

Dry Weights (DW). DW were recorded after the fresh weights had spent 3 days in an oven with a temperature of 175°F. Like FW, SGG (8.25 lbs N/ 5000 ft^2) had a high DW at 5 WAA, but with statistical similarities to SGG (6.6 lbs N/ 5000 ft^2) (Table 6). Of the three labeled rates: SGP (3.3 lbs of N/5000 ft^2), SGG (3.3 lbs of N/5000 ft^2), and SOC (3.201 lbs of N/4000 ft^2), all three treatments had similar DW. At 10 WAA there where few differences, however the two SGG treatments (8.25 lbs N/ 5000 ft^2 and 6.6 lbs N/ 5000 ft^2) had significantly heavier DW than the Urea-ammonium nitrate and the control treatments.

Conclusion

When applying fertilizer to Hybrid Bermudagrass (*Cynodon dactylon* x *Cynodon transvaalensis*) for spring green-up: SGG, SGP, SOC, and Sodium Nitrate are all options compared to a traditional synthetic fertilizer, Urea- ammonium nitrate. Based strictly on VR, FW, and DW, it would be difficult to choose between the marketed manufactured organic fertilizers at their specific labeled rates. SGG and SGP carry recommended labeled coverage of 5000 ft^2 per 30 lb bag, where application of SOC is based on recommended 4000 ft^2 per 29.1 lb bag. SOC label applies more N/foot than Secret Garden products, but when considering VR, FW, and DW, SGG and SGP labeled rates performed as well and some times better than SOC labeled rate. Also price must be considered as well and Secret Garden Products $6.02/ lb N, while is SOC is $6.69/ lb N at lawn garden chain stores. SGG and SGP would be the better choice than SOC based on the results of this study when considering price per lb of N, VR, and LCC. The manufactured organic fertilizers tested could all be options for consumers when compared to other traditional synthetic fertilizers, and therefore may be a better option for consumers looking for a product marketed as more sustainable.

For spring green-up the 10.4g of SGG/1.53 ft^2 (8.25 lbs N/ 5000 ft^2) had very good results in VR, FW, and DW. SGG may exhibit quicker N availability because of its N make up of 1% nitrate N, 0.25% ammoniacal N, 0.75% water soluble N. SGP according to the label is supposed to contain the same amount of available N, but the particles have less surface area because of their larger particle size contribution seen in chapter 2. Therefore N may not be available as quickly and evenly throughout a stand of turfgrass due to the particle size of SGP. SOC does not contain as much available N with only 0.11% ammoniacal N and 0.89% water soluble N. This may contribute to SGG outperforming SOC in FW. It may be of benefit for the manufacturers to label and rate for spring green-up for this specific product. SGG then could be marketed as organic fertilizer designed for spring green-up. This may provide more sales to the manufacturers while also providing customers with a product that is marketed as sustainable and natural to customers who desire to use one for spring green-up.

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Table 5. Visual ratings[z] for Hybrid Bermuda greenhouse trial at 2, 3, 4, 5, 8, 9, 10, and 11 WAA[y].

Fertilizer	Rate (g /1.53ft.^{2})	Nitrogen lbs N/5000ft.^{2}	2WAA	3WAA	4WAA	5WAA	8WAA	9WAA	10WAA	11WAA
Secret Garden Granular	4.2	3.3[w]	2.42bc[x]	2.71cdef	2.85bc	2.85bc	1.85ab	1.71bc	2.28ab	2.14ab
11-2-3	5.2	4.125	2.57abc	3.28bcd	3.14abc	3.28bc	2.00ab	2.28abc	2.57ab	2.57ab
	8.3	6.6	3.00ab	3.71ab	3.57ab	3.71ab	2.00ab	2.28abc	2.85a	2.85a
	10.4	8.25	3.42a	4.14a	4.00a	4.28a	2.00ab	2.57ab	3.14a	2.85a
Secret Garden Pelletized	4.2	3.3[w]	2.42bc	2.57def	2.57c	2.85bc	2.14ab	2.14abc	2.42ab	2.42ab
11-2-3	5.2	4.125	2.57abc	3.00bcde	2.71bc	3.00bc	2.14ab	2.28abc	2.57ab	2.57ab
	8.3	6.6	2.57abc	3.00bcde	3.00bc	3.00bc	2.00ab	2.57ab	2.85a	3.00a
	10.4	8.25	2.42bc	3.42abc	3.14abc	3.28bc	2.42a	2.85a	3.14a	3.00a
Scott's Organic Choice	5.1	4.001[w]	2.00cd	2.71cdef	2.28c	2.85bc	2.14ab	2.28abc	2.71ab	2.42ab
11-2-2	10.1	8.002	2.57abc	2.71cdef	3.00bc	3.28bc	2.42a	2.85a	3.00a	2.85a
Sodium Nitrate	185	3.26	2.42bc	2.85cde	2.85bc	2.85bc	2.14ab	2.14abc	2.28ab	2.14ab
Urea-ammonium nitrate	90	3.12	2.42bc	2.42ef	2.42c	2.57cd	1.85ab	1.85abc	2.00ab	2.00ab
Non Fertilized Control	***	***	1.28d	2.00f	1.14d	1.71d	1.71b	1.42c	1.42b	1.57b

[z]Visual Ratings were based off the scale: 0 = dead, 1 = no apparent change in aesthetics or greenness, 2 = a very mild change in greenness and not uniform, 3 = a mild change in greenness, 4 = a distinct difference in greenness, but not uniform, and 5 = a distinct difference in greenness throughout.

[y]Weeks after application.

[x]Means within column followed by the same letter are not significantly different (Tukey's Studentized Range Test, $\alpha = 0.05$).

[w]Labeled Rates.

Table 6. Fresh weights[z] (5 WAA[y]) and dry weights[x] (5 WAA and 10 WAA) for Hybrid Bermuda greenhouse trial.

Fertilizer	Rate	Nitrogen	Fresh Weights	Dry Weights	
	(g /1.53ft.^{2})	lbs N/5000ft.^{2}	5 WAA	5 WAA	10 WAA
Secret Garden Granular	4.2	3.3[w]	26.87def[v]	9.17cde	10.21ab
11-2-3	5.2	4.125	31.42de	10.31bcde	11.35ab
	8.3	6.6	40.38b	13.20ab	13.35a
	10.4	8.25	50.40a	15.84a	14.22a
Secret Garden Pelletized	4.2	3.3[w]	26.88def	8.98cde	11.08ab
11-2-3	5.2	4.125	32.24cde	10.42bcde	11.51ab
	8.3	6.6	33.40cd	11.18bcd	10.38ab
	10.4	8.25	38.85bc	11.94bc	11.97ab
Scott's Organic Choice	5.1	4.001[w]	24.94ef	8.78de	10.80ab
11-2-2	10.1	8.002	30.30de	9.97cde	11.27ab
Sodium Nitrate	185	3.26	27.30def	8.85de	9.54ab
Urea-ammonium nitrate	90	3.12	21.45f	7.54ef	7.57b
Non Fertilized Control	***	***	12.31g	4.95f	7.72b

[z]Fresh weights measured in grams.

[y]Weeks after application.

[x]Dry weights measured in grams.

[w]Labeled Rates.

[v]Means within column followed by the same letter are not significantly different (Tukey's Studentized Range Test, $\alpha = 0.05$).

CHAPTER V

Evaluation of an Organic Soilless Substrate in Vegetable Production

Significance to the Industry

Home vegetable gardening has begun to regain popularity over the last few years. With the "green" movement in full swing many home gardeners are looking for new methods to become "organic" or sustainable in the way they produce vegetables. Organic soilless substrates in raised beds may be a way for homeowners to achieve their vision of sustainability. This study evaluated the growth of two vegetables, squash and cabbage, grown in different depths of manufactured organic compost applied to the surface of earthen beds. There were no significant differences in total fruit yield among the treatments of different depths of compost and the non-amended earthen bed control for the entirety of the study.

Introduction

Handling and application of organic wastes is often problematic due to bulk, odor or government regulations. Composting is generally the primary way to cope with disposal problems of organic wastes. Composting will typically help eliminate the odor and reduce the bulk dramatically of raw organic wastes (Adediran et al., 2003) by breaking down the raw organic material to nutrients in a decomposed state, allowing organic wastes to complement each other. When one organic material is lacking in N but has a favorable C:N ratio, another waste with high amounts of N can be composted with it to provide a suitable compost and fertilizer

(Harp et al., 2008). Other circumstances have to be considered while composting. Type, time, and materials to be composted must be examined while producing compost. There are several different ways to compost, with duration for each process type being one of the main factors impacting the resulting compost (Buchanan and Gliessman, 1991). Composting solves many problems related to raw wastes being exposed to humans and animals through crops (Lopez-Mosquera et al., 2007). Composting municipal solid waste has been studied as an amendment for okra and watermelon production. With increasing rates of municipal solid waste incorporation to the soil, there was an increase in yield for both okra and watermelon though watermelon was not significantly different. Increased yields where likely because of improved soil physical and chemical properties (Lu et al., 2008).

The demand for environmentally friendly products has contributed greatly to an increased awareness about the “greenness” of manufactured products. Consumers, investors, environmental interest groups, and government are applying pressure to the manufacturers and others to provide green materials. A “Green” focus has changed the priorities of many companies. Initially, governments were reluctant to go “green” (Roarty, 1997). Governments have since taken a proactive role in a more sustainable community and country. In the United States, State lawmakers are writing legislation to regulate fertilization practices. In Washington state politicians and industry are at odds because of regulations being passed by the government. Industry leaders accuse the politicians of writing laws without actual science backing them (White, 2011). Over time, manufacturers and landscape management firms are starting to incorporate environmentally friendly business criteria into their marketing and maintenance plans. As a part of these plans, manufacturers have begun to create “green” products, which are generally marketed as organic, along with other characteristics such as: natural, non-toxic, sustainable, and recyclable (Roarty, 1997). In 2010, the organic industry was valued at $29 billion dollars with the organic supplements sector valued at $681 million dollars, which was a 7.4% increase from 2009 (Kuack, 2011).

Now with emphasis on organic production, many different sources of organic nutrition have been sought out by developing countries as well as industrialized nations. Organic wastes include: animal manures, crop residues, sewage sludge, food processing wastes, industrial organic wastes, logging manufacturing wastes, municipal refuse, and many other types of organic substances (Harp et al., 2008; Parr et al., 1986).

Previous research has been conducted on the effect of composted municipal solid waste as a soil amendment for growth of vegetables. Crop yield, and heavy metal concentration within the eatable parts of the vegetable were evaluated. Compost had positive effects on yield, but did not cause increased amounts of heavy metals in edible parts of the vegetables that would be detrimental if consumed (Lu et al., 2008).

The objective of this study was to compare total fruit yields for squash (*Cucurbita pepo*) and for Cabbage (*Brassica oleracea* var. capitata) grown in raised beds using manufactured organic compost that was surface applied to earthen beds compared with non-amended beds.

Materials and Methods

The study was installed on August 18, 2010 with three different depths of Jungle Growth Vegetable and Flower mix compared to a control in the native soil. Treatments were: non-amended native soil; 1 in. of compost (2 commercially sold bags); 2 in. of compost (4 commercially sold bags); and 3 in. of compost (6 commercially sold bags). The plant material was seeded squash (*Cucurbita pepo*) and cabbage (*Brassica oleracea* var. capitata). The study was conducted at the North Alabama Horticulture Research Center, Cullman, Alabama (34°11'34.75"N x 86°47'41.95"W, USDA Hardiness Zone 7b) in a Hartselle fine sandy loam soil.

Initial stands and weights of the squash were recorded October 4, 2010, 47 days after planting (DAP). Stands and weights were also recorded at 51 DAP, 54 DAP, 57 DAP, 61 DAP, 64 DAP, 66 DAP, and 71 DAP. Cabbage was harvested and weighed fresh November 29, 2010, 104 DAP.

The two species were treated as individual experiments with 4 different treatments for each species. Both plots were arranged in a randomized complete block design with five replications. Data collected were subjected to Duncan's Multiple Range Test (P = 0.05).

Results and Discussion

For the squash, there were no significant differences in total fruit yield among treatments throughout the entire study (Table 7.). At 47 DAP the Jungle Growth Flower and Vegetable mix at the depth of 3 in. produced the heaviest amount of squash at an average of 2.58 lbs. per plant; however, this was not significantly greater than other treatments of the compost or the non-composted treatment. The treatments at a depth of 3 in. of compost produced the heaviest crop, though not statistically, for 5 out of the 8 harvests (Table 7).

Cabbage had no significant difference among treatments at harvest (Table 8). The control with no compost produced the heaviest yield, while the 1 in. depth treatment of Jungle Growth Flower and Vegetable mix had the heaviest yield of the compost treatments. Increasing the depth of compost produced smaller yields (Table 8).

Conclusion

If a gardener is looking for manufactured organic compost for raised bed gardening of squash, Jungle Growth Flower and Vegetable mix can be a viable option when compared to non-amended earthen beds. The same recommendations can be made for cabbage gardening, as there were no significant differences between non-amended earthen beds and those amended with manufactured organic compost. The manufactured organic compost tested could be an option at the different depths for consumers when compared to traditional non-amended earthen beds. Therefore, Jungle Growth Flower and Vegetable mix may be a better option for consumers looking for a product marketed as more sustainable, particularly where container production and raised beds are the most practical for space available for small plots of garden vegetables. The bulk density (17.7 lbs/ $ft.^3$) of Jungle Growth Flower and Vegetable mix is easier to transport than earth soil.

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Table 7. Squash yields[z] for manufactured compost trial at 47, 51, 54, 57, 61, 64 , 66, and 71 DAP[y] .

Treatments	Depths	47DAP	51DAP	54DAP	57DAP	61DAP	64DAP	66DAP	71DAP
Jungle Growth Flower	1 in.	1.69a[x]	0.98a	0.85a	2.13a	0.93a	1.51a	1.69a	1.83a
and Vegetable Mix	2 in.	1.64a	1.84a	1.10a	2.28a	1.25a	1.40a	1.36a	1.08a
	3 in.	2.58a	2.24a	2.62a	1.08a	2.20a	2.63a	2.17a	1.19a
No Compost Control	***	2.44a	2.58a	2.36a	1.14a	1.65a	1.64a	1.49a	1.64a

[z]Yields were measured in lbs/plant.

[y]Days after planting.

[x]Means within column followed by the same letter are not significantly different (Duncan's Multiple Range Test, $\alpha = 0.05$).

Table 8. Cabbage yields^z for manufactured compost trial at 104 DAP^y .

Treatments	Depths	104DAP
Jungle Growth Flower and Vegetable Mix	1 in.	56.41a^x
	2 in.	55.40a
	3 in.	51.58a
No Compost Control	***	62.56a

^{z}Yields were measured in lbs/plot.

^{y}Days after planting.

^{x}Means within column followed by the same letter are not significantly different (Duncan's Multiple Range Test, α = 0.05).

CHAPTER VI

Final Discussion

The purpose of these studies was to evaluate multiple manufactured organic amendments for use by consumers. With the "green" movement growing in popularity over the past few years, manufacturers have tried to take advantage of this economic environment by marketing products as organic, natural, sustainable, and recyclable. Many manufacturers have sold these products to landscape managers and homeowners with very little research to document their effectiveness. These studies evaluated the following: the physical properties of commercially available organic fertilizers, the effects on the aesthetics on turf following applications of commercially available organic fertilizers, and the growth of vegetables grown in different depths of manufactured organic compost applied to the surface of earthen beds.

In Chapter 2, both the particle size distribution and disintegration rates of commercially available organic fertilizers were studied according to a procedure from the International Fertilizer Development Center (IDFC). Particle sizes were different among the three fertilizers evaluated. This may affect the spreadability and ease of coverage of the fertilizer, which in turn will also affect the rate at which it must be applied. Disintegration rates could have an effect on how fast N is available to the plant because it is the first step to solubility. In the first 60 seconds Secret Garden Granular (SGG) disintegrated more quickly, however by 300 seconds Secret Garden Pelletized (SGP) had disintegrated the most. To determine more equivalent disintegration rates, comparing a granular product to a pelletized product, the same size sieve was used in a third experiment. SGP, SGG, and SOC were disintegrated in water for 480 seconds. There were no differences in dry weights left un-disintegrated.

In Chapter 3, manufactured organic fertilizers and synthetic fertilizers were compared following application of the products according to the aesthetic quality of Meyer Zoysiagrass (*Zoysia japonica* 'Meyer'). Leaf chlorophyll content (LCC) and visual ratings (VR) were used to determine aesthetic quality of the turfgrass. Our results showed that all of the manufactured organic fertilizers were suitable for obtaining aesthetically pleasing Meyer Zoysiagrass. It was also found that doubling the labeled rates showed better results in VR and LCC, and there were no perceived problems when considering only these variables. More research could be done examining other variables while doubling the rates of the fertilizers. The experiment could also be tested further to continue the research process.

In Chapter 4 a study was conducted evaluating the same fertilizer treatments as the previous chapter on Hybrid Bermudagrass (*Cynodon dactylon* x *Cynodon transvaalensis*) spring green-up in a greenhouse. VR were again used to measure aesthetic quality, and yields of fresh weights and dry weights were also recorded. Again it was determined that the manufactured organic fertilizers were effective in producing quality turfgrass. It was also seen that SGG had a faster effect on the spring green-up of Hybrid Bermudagrass than the other treatments. It is suggested that the manufacturers market SGG as a spring green-up product. This experiment could also be tested again for consistency of results and to continue the experimental process.

In Chapter 5, Jungle Growth Flower and Vegetable mix was used to amend raised earthen beds for squash (*Cucurbita pepo*) and cabbage (*Brassica oleracea* var. capitata) production. Weights of total fruit yields were determined at different intervals throughout the study on squash. Cabbage yields were weighed at termination of the study. There were no differences in this study among any of the treatments for squash or cabbage. It is suggested that consumers use Jungle Growth Flower and Vegetable mix in a raised bed setting without losing yields when compared to traditional non-amended earthen raised beds. This experiment could also be repeated to further the research process and to test the results.