USCC Factsheet: Compost and Its Benefits[1]

What is Compost?

Compost is the product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth. Compost bears little physical resemblance to the raw material from which it originated.


Photo: Larry Strong

Compost is an organic matter resource that has the unique ability to improve the chemical, physical, and biological characteristics of soils or growing media. It contains plant nutrients but is typically not characterized as a fertilizer.

How is Compost Produced?

Compost is produced through the activity of aerobic (oxygen-requiring) microorganisms. These microbes require oxygen, moisture, and food in order to grow and multiply. When these factors are maintained at optimal levels, the natural decomposition process is greatly accelerated. The microbes generate heat, water vapor, and carbon dioxide as they transform raw materials into a stable soil conditioner. Active composting is typically characterized by a high-temperature phase that sanitizes the product and allows a high rate of decomposition, followed by a lower-temperature phase that allows the product to stabilize while still decomposing at a lower rate. Compost can be produced from many "feedstocks" (the raw organic materials, such as leaves, manures or food scraps). State and federal regulations exist to ensure that only safe and environmentally beneficial composts are marketed.

Benefits of Compost and its Effects on Soils and Plants

Thanks to its many attributes, compost is extremely versatile and beneficial in many applications. Compost has the unique ability to improve the properties of soils and growing media physically (structurally), chemically (nutritionally), and biologically. Although some equate the benefit of compost use to lush green growth, caused by plant-available nitrogen, the real benefits of using compost are long-term and related to its organic matter content.

Benefits of Using Compost

- Improves the soil structure, porosity, and density, thus creating a better plant root environment.
- Increases infiltration and permeability of heavy soils, thus reducing erosion and runoff.
- Improves water holding capacity, thus reducing water loss and leaching in sandy soils.
- Supplies a variety of macro and micronutrients.
- May control or suppress certain soil-borne plant pathogens.
- Supplies significant quantities of organic matter.
- Improves cation exchange capacity (CEC) of soils and growing media, thus improving their ability to hold nutrients for plant use.
- Supplies beneficial microorganisms to soils and growing media.
- Improves and stabilizes soil pH.
- Can bind and degrade specific pollutants.

Physical Benefits

Improved Structure

Compost can greatly enhance the physical structure of soil. In fine-textured (clay, clay loam) soils, the addition of compost will reduce bulk density, improve friability (workability) and porosity, and increase its gas and water permeability, thus reducing erosion. When used in sufficient quantities, the addition of compost has both an immediate and long-term positive impact on soil structure. It resists compaction in fine-textured soils and increases water holding capacity and improves soil aggregation in coarse-textured (sandy) soils. The soil-binding properties of compost are due to its humus content. Humus is a stable residue resulting from a high degree of organic matter decomposition. The constituents of the humus act as a soil 'glue,' holding soil particles together, making them more resistant to erosion and improving the soil's ability to hold moisture.

Moisture Management

The addition of compost may provide greater drought resistance and more efficient water utilization. Therefore, the frequency and intensity of irrigation may be reduced. Recent research also suggests that the addition of compost in sandy soils can facilitate moisture dispersion by allowing water to more readily move laterally from its point of application.

Chemical Benefits

Modifies and Stabilizes pH

The addition of compost to soil may modify the pH of the final mix. Depending on the pH of the compost and of the native soil, compost addition may raise or lower the soil/compost blend's pH. Therefore, the addition of a neutral to slightly alkaline compost to an acidic soil will increase soil pH if added in appropriate quantities. In specific conditions, compost has

[1] Excerpted from the Field Guide to Compost Use, ©2001 The United States Composting Council

been found to affect soil pH even when applied at quantities as low as 10-20 tons per acre. The incorporation of compost also has the ability to buffer or stabilize soil pH, whereby it will more effectively resist pH change.

Increases Cation Exchange Capacity

Compost will also improve the cation exchange capacity of soils, enabling them to retain nutrients longer. It will also allow crops to more effectively utilize nutrients, while reducing nutrient loss by leaching. For this reason, the fertility of soils is often tied to their organic matter content. Improving the cation exchange capacity of sandy soils by adding compost can greatly improve the retention of plant nutrients in the root zone.

Provides Nutrients

Compost products contain a considerable variety of macro and micronutrients. Although often seen as a good source of nitrogen, phosphorous, and potassium, compost also contains micronutrients essential for plant growth. Since compost contains relatively stable sources of organic matter, these nutrients are supplied in a slow-release form. On a pound-by-pound basis, large quantities of nutrients are not typically found in compost in comparison to most commercial fertilizers. However, compost is usually applied at much greater rates; therefore, it can have a significant cumulative effect on nutrient availability. The addition of compost can affect both fertilizer and pH adjustment (lime/sulfur addition). Compost not only provides some nutrition, but often makes current fertilizer programs more effective.

Biological Benefits

Provides Soil Biota

The activity of soil organisms is essential in productive soils and for healthy plants. Their activity is largely based on the presence of organic matter. Soil microorganisms include bacteria, protozoa, actinomycetes, and fungi. They are not only found within compost, but proliferate within soil media. Microorganisms play an important role in organic matter decomposition which, in turn, leads to humus formation and nutrient availability. Microorganisms can also promote root activity as specific fungi work symbiotically with plant roots, assisting them in the extraction of nutrients from soils. Sufficient levels of organic matter also encourage the growth of earthworms, which through tunneling, increase water infiltration and aeration.

Suppresses Plant Diseases

Disease incidence on many plants may be influenced by the level and type of organic matter and microorganisms present in soils. Research has shown that increased population of certain microorganisms may suppress specific plant diseases such as pythium and fusarium as well as nematodes. Efforts are being made to optimize the composting process in order to increase the population of these beneficial microbes.

Additional Benefits of Compost

Some additional benefits of compost have been identified, and has led to new uses for it. These benefits and uses are described below.

Binds Contaminants

Compost has the ability to bind heavy metals and other contaminants, reducing both their leachability and absorption by plants. Therefore, sites contaminated with various pollutants may often be improved by amending the native soil with compost. The same binding affect allows compost to be used as a filter media for storm water treatment and has been shown to minimize leaching of pesticides in soil systems.

Degrades Compounds

The microbes found in compost are also able to degrade some toxic organic compounds, including petroleum (hydrocarbons). This is one of the reasons why compost is being used in bioremediation of petroleum contaminated soils.

Wetland Restoration

Compost has also been used for the restoration of native wetlands. Rich in organic matter and microbial population, compost and soil/compost blends can closely simulate the characteristics of wetland soils, thereby encouraging the re-establishment of native plant species.

Erosion Control

Coarser composts have been used with great success as a mulch for erosion control and have been successfully used on sites where conventional erosion control methods have not performed well. In Europe, fine compost has been mixed with water and sprayed onto slopes to control erosion.

Weed Control

Immature composts or ones which possess substances detrimental to plant growth (phytotoxins), are also being tested as an alternative to plastic mulches for vegetable and fruit production. While aiding in moisture conservation and moderating soil temperatures, immature composts also can act as mild herbicides.

A Bright Future

With these many benefits and its myriad of applications, from the traditional growing of plants to novel uses in stormwater management and climate change mitigation, the production and use of compost has a bright future indeed!

US Composting Council
www.compostingcouncil.org

About the USCC: The United States Composting Council (USCC) is a national not-for-profit organization dedicated to the development, expansion and promotion of the composting industry. For more information visit www.compostingcouncil.org

Natural Resouces Conservation Service

USDA

HEALTHY SOILS ARE: *high in organic matter.*

Losing Organic Matter

Organic matter is vital to healthy soils, yet most modern agricultural operations are not managed in ways to retain high levels. Only half the original organic matter remains in most modern cultivated soils. In general, organic matter levels have fallen from 5-6 percent of the soil to less than 3 percent on most cropland soils.

Using tillage depletes organic matter. Each time the soil is tilled, oxygen is stirred into it, stimulating microbial action to decompose organic matter at an accelerated rate. As a matter of fact, when a woodland is cleared and planted or a prairie is plowed, most of the organic matter that was built over hundreds of years is lost within 10 years of tillage.

Combining frequent tillage with farming practices that leave little plant residue for soil microbes to eat (such as burning or removing crop residues) will lead to the depletion of organic matter.

unlock the SECRETS IN THE SOIL

ORGANIC MATTER *matters.* IN FACT, THERE MAY BE NO OTHER COMPONENT THAT'S MORE IMPORTANT TO A HEALTHY SOIL THAN ORGANIC MATTER.

The tiny fraction of soil composed of anything and everything that once lived—organic matter—is more than an indicator of healthy soils.

The carbon in organic matter is the main source of energy for the all-important soil microbes and is also the key for making nutrients available to plants. The list of positive influences high levels of organic matter have on healthy soils includes:

1. Provides a carbon and energy source for soil microbes
2. Stabilizes and holds soil particles together
3. Supplies, stores, and retains such nutrients as nitrogen, phosphorusand sulfur
4. Improves the soil's ability to store and move air and water
5. Contributes to lower soil bulk density and less compaction
6. Makes soil more friable, less sticky, and easier to work
7. Retains carbon from the atmosphere and other sources
8. Reduces the negative environmental effects of pesticides, heavy metals and other pollutants
9. Improves soil tilth in surface horizons
10. Increases water infiltration rates
11. Reduces crusting
12. Reduces water runoff
13. Encourages plant root development and penetration
14. Reduces soil erosion

HEALTHY SOILS ARE: *high in organic matter.*

Considering the long list of benefits organic matter has on soil health and crop production, increasing organic matter may well be the most important management step a producer can take to improve a farm's profitability and sustainability. In general, there are three ways to do that:

1. Increase the amount of plant and root production;
2. apply carbon-rich materials to the soil; and
3. use practices that slow rather than speed decomposition.

Cover crops, green manure crops, and perennial forage crops add organic matter, as do compost and manure. Growing crops and roots add biomass above and below the soil surface. However, not all that biomass is converted to soil organic matter—much of it is released as carbon dioxide and water. It can take 20,000 pounds of organic inputs such as crop residue to increase the actual soil organic matter from 4 percent to 5 percent.

Compost in particular breaks down more slowly and improves soil structure more quickly than other organic materials. Manure breaks down quickly to add nutrients for crops, but takes longer to improve the soil than compost.

COMPARING ACTIVE AND STABILIZED ORGANIC MATTER

	PORTION OF ALL ORGANIC MATTER	DECOMPOSITION TIME	FUNCTIONAL IMPORTANCE
ACTIVE	One-half to two-thirds	Up to several decades	Decomposes organic material to produce plant nutrients
STABILIZED	One-third to one-half	A century or more	Exceptional water holding capacity, soil structure benefits; reservoir for nutrients, including carbon

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Active and Stabilized Organic Matter

Organic matter can be divided into two categories: active and stabilized. The portion made of fresh organic material and living organisms, as well as partially decomposed material that is slowly decomposing, is called "active organic matter."

Active organic matter and the microbes that feed on it are central to nutrient cycles in the soil. Nutrients, especially nitrogen, phosphorus, and sulfur, are held in this active organic matter until soil organisms release them for plant use.

This accounts for there being much more nutrient volume in the soil than is available for plant use at any one time. For example, a soil with 3 percent organic matter contains about 3,000 pounds per acre of nitrogen, but only a small part of that (30-100 pounds) may become available to plants in any one year, depending on decomposition rates.

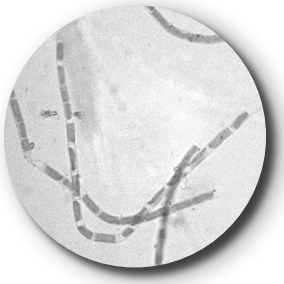
While active organic matter may decompose over a few decades, the stabilized portion of organic matter is made of larger, more complex compounds that are much more difficult for microbes to degrade. Much of the stabilized organic matter in the soil is highly decomposed plant and animal tissues that grew more than a century, and possibly several centuries, ago. This organic matter becomes carbon-rich humus that's resistant to further decay.

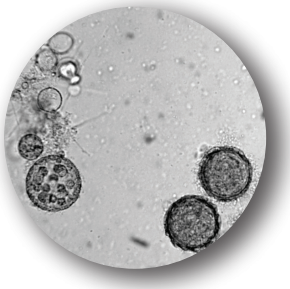
"Stabilized organic matter" or humus, acts like a sponge and can absorb six times its weight in water. It's also a reservoir for nutrient storage, sequestering carbon from the atmosphere and other sources.

Healthy soils need both active and stabilized organic matter to function well.

USDA

HEALTHY SOILS ARE: *full of life.*





MANY PEOPLE DON'T REALIZE THAT SOIL, ESPECIALLY HEALTHY SOIL, IS FULL OF LIFE.

Many people don't realize that soil, especially healthy soil, is full of life. Millions of species and billions of organisms make up a complex and diverse mix of microscopic and macroscopic life that represents the greatest concentration of biomass anywhere on the planet.

Bacteria, algae, microscopic insects, earthworms, beetles, ants, mites, and fungi are among them. All together, their value has been estimated at $1.5 trillion a year worldwide.

Estimates vary, but if you could weigh all the organisms in the top six inches of soil on an acre of land, you'd find they would weigh between 2,500 pounds to more than 5,000 pounds, depending on how healthy the soil is. That is a LOT of life.

What these low-lying creatures lack in size, they make up for in numbers. Consider bacteria, the soil microbes with the highest numbers, for example. You can fit 40 million of them on the end of one pin. In fact, there are more soil microorganisms (microbes for short) in a teaspoonful of soil than there are people on the earth.

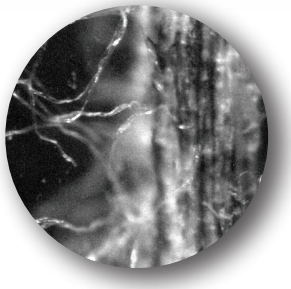
These microbes, which make up only one-half of one percent of the total soil mass, are the yeasts, algae, protozoa, bacteria, nematodes, and fungi that process soil into rich, dark, stable humus.

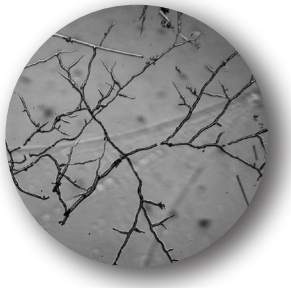
Like other living creatures, the organisms in the soil also need food and shelter. Some feed on dead organic matter, and some eat other microbes. As a group, they cycle nutrients, build the soil and give it structure.

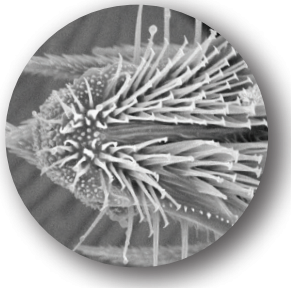
The healthiest soils are those with a diversity and abundance of life. Farmers with the healthiest soils nurture that life by creating a diversity of plant life above the soil surface, with year-round ground cover, no tillage, and judicious pesticide use.

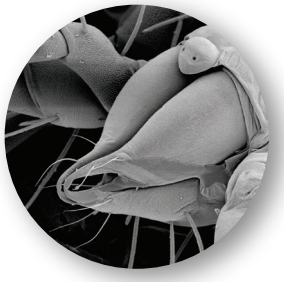
unlock the SECRETS IN THE SOIL

HEALTHY SOILS ARE: *full of life.*









Fully realizing the soil is full of life is a game-changer for producers who are farming with healthy soils in mind. For those producers, farming centers around feeding the organisms that build healthy soils.

These farmers understand that tillage, the turning of the soil that has been the standard for growing crops for years and years, is disruptive to soil microbes and destructive to the soil system.

Instead, they disturb the soil as little as possible. And, they grow a diversity of living plants in the soil as much of the time as practical, covering the soil and offering food to soil microbes through living roots. Those soil organisms, in turn, cycle nutrients back to the plant, allowing it to grow and flourish.

It's a natural, symbiotic system that leads to healthy soils and more sustainable and profitable agriculture.

ORGANISM	WHAT DOES IT DO?
BACTERIA	Feed on organic matter, store and cycle nitrogen, and decompose pesticides.
FUNGI	Up to 3,000 species of fungi are in the soil. Some feed on dead organic matter like crop residues that are more difficult to break down–others are parasites that attack other microbes. Some fan out from the root to get more nutrients and hold more water for the plant, delivering nutrients to the plant in exchange for carbon.
PROTOZOA	Eat bacteria, fungi, and algae. When they eat bacteria, their main food source, they unlock nitrogen that's released into the soil environment slowly. They convert organic nitrogen to inorganic nitrogen that's available to plants.
MITES	Decompose and shred organic matter as an important part of the nitrogen cycle.
NEMATODES	These microscopic worms are an important part of the nitrogen cycle. Most are non-pathogenic and don't cause disease. They eat other organisms in the soil.
EARTHWORMS	Expel partially decomposed organic matter, produce nutrient-rich casts, and make lubricated tunnels that aid soil structure and water movement in the soil.

Note: It's important to know how these organisms contribute to building healthy soil, but it's also important to know what harms them. Both tillage and the non-judicious use of pesticides can harm these important organisms.

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COMPOST
THE SUSTAINABLE SOLUTION
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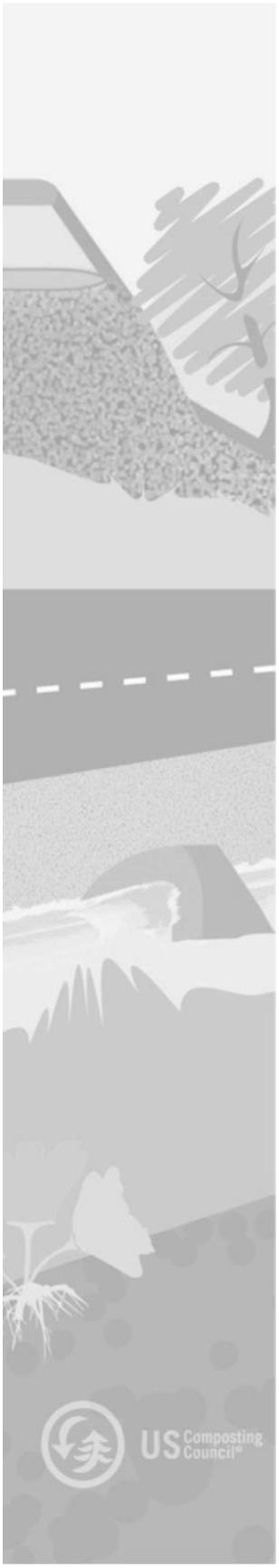
Increasing Soil Organic Matter with Compost



"Essentially, all life depends upon the soil ... There can be no life without soil and no soil without life; they have evolved together." Charles E. Kellogg, USDA Yearbook of Agriculture, 1938

The addition of compost to the soil will improve any soil's physical, chemical and biological properties; yielding healthier soil, plants, turfgrass, trees and shrubs, helping to reduce project costs. Compost is a great source of **Soil Organic Matter**, which offers a variety of benefits proclaimed by university research, actual field use and even regulatory agencies.

Essentially, amending soil with compost enhances the growth of ALL plant life, because the soil that they live in is improved and healthier!

AAPFCO (Association of American Plant Food Control Officials) consists of state Department of Agriculture officials from across the US. They regulate all claims made by compost manufacturers on product labels, literature and websites (subject to individual state approval). The following list, from their **Rules and Regulations for Bulk Compost**, has been **accepted as valid for the benefits of compost:**

- Improves soil structure and porosity – creating a better plant root environment
- Increases moisture infiltration and permeability, and reduces bulk density of heavy soils, improving moisture infiltration rates and reducing erosion and runoff
- **Improves the moisture holding capacity of light soils – reducing water loss and nutrient leaching, and improving moisture retention**
- Improves the cation exchange capacity (CEC) of soils
- **Supplies Organic Matter**
- Aids the proliferation of soil microorganisms
- Supplies beneficial microorganisms to soils and growing media
- Encourages vigorous root growth
- Allows plants to more effectively utilize nutrients, while reducing nutrient loss by leaching
- Enables soils to retain nutrients longer
- Contains humus – assisting in soil aggregation, making nutrients available for plant uptake
- Buffers soil pH

Compost Benefits: Beyond the plants!

The benefits outlined above are typically regarded as aids to **Plant Growth**, but they are far more than that. They also pertain to how compost improves the soil, which impacts overall soil and plant quality, but also water quality and quantity …. And therefore, the environment, and human existence (and quality of life). By adding compost which contains stabilized organic matter to the soil, you are helping the overall health of the soil:

1. Be protected from wind and water erosion
2. Retain larger volumes of water, and
3. Filter out and/or bind contaminants that might be contained in surface water.

These benefits are so important that municipal ordinances, rules and Best Management Practices (BMP) are appearing around the country that requires the addition of organic matter (OM) to the soil. One example is the following ordinance (*see reverse page*) contained in the Denver Water Authority Rules[2]:

Denver Water operating rules that apply to soil amendment and limits on use: Operating Rule 14.02.4. Soil Amendment for Irrigation of Turf at Newly Licensed Premises: Proof of proper soil preparation is required before installation of plant material. Penalties of $1,000 may apply if soil amendment is not completed and approved by Denver Water prior to the installation of plant material. **Proper soil amendment is the equivalent of adding approved compost at a rate of four cubic yards per 1,000 square feet of permeable area, incorporated (rototilled) to a depth of six inches.** *There are other rules and BMPs like this across the country.*

Facts & Benefits: Water use reduction and conservation

1. A University of Illinois study[3] about amending farmland soil with compost produced the following facts:
    - In sandy soils, compost will increase water holding capacity by absorbing water.
    - In high clay content soils, compost will improve aggregation, allowing water to move through soil faster. Following a 2nd application of amendments (i.e., compost) all amended plots increased Plant Available Water by 5 to 45% compared to the control.
    - This would have potentially reduced the average amount of irrigation water needed by 10 to 90%
    - At current prices, a reduction of one irrigation cycle would reduce energy costs by $270 to $620 on a 160 acre system, depending on the energy source used.
2. The Recycled Organics Units of New South Wales in Australia conducted a Life Cycle Analysis of compost[4]:
    [Compost use] reduced irrigation water from increased water holding capacity of 3 to 10%, thereby saving 14,000 to 100,000 gallons/acre/year.

WHY USE COMPOST?
Because amending soil with Compost will significantly reduce water use!

For every 1% increase in organic matter in your soil, you increase water retention at the rate of 3 quarts per cubic foot, OR each increase of 1% OM can increase soil water holding capacity by 27,000 gallons H2O/Acre[6] (this will vary depending on soil type).

Facts & Benefits: Bioremediation

- Bioremediation uses compost to clean and restore contaminated soils by degrading and binding contaminants in soil. The process has been used both in-situ, where compost and other amendments are incorporated into a contaminated soil, and by removing the contaminated soils and adding them to a compost pile[5].

Facts & Benefits: Resource conservation

- Applying just 2" of compost in lieu of the traditional 6" of 'topsoil', which is typically of unknown origin and quality, reduces project material costs by up to 2/3! The compost will provide additional benefits, as described above, that commercial topsoil just cannot offer.

The US Composting Council supports and strongly recommends regular compost testing to insure product quality and safety. The Seal of Testing Assurance Program (STA) is the ONLY nationally recognized compost testing program. Read more about it at: http://compostingcouncil.org/seal-of-testing-assurance/

US Composting Council Seal of Testing Assurance

Cited References

[1]Compost-New Applications for an Age Old Technology, USEPA530-F-97-047
[2]Denver Water Authority – Soil Amendment Program
http://www.denverwater.org/Conservation/SoilAmendmentProgram/
[3]Using Compost to Reduce Irrigation Needs
http://www.usawaterquality.org/conferences/2007/PPTs&Posters/AgBMPs/Friend.pdf
[4]Sharma G and Campbell A, 2003, Life Cycle Inventory and Life Cycle Assessment for Windrow Composting Systems, Recycled Organics Unit, New South Wales Department of Environment and Conservation, Sydney, NSW, Australia
[5]Summarized from "Innovative Uses of Compost: Bioremediation and Pollution Prevention", USEPA 1997
[6]USDA NCRS Soil Health Key Points, Feb. 2013

Other Useful References

How To: Soil Best Management Practices, Tools, & Specifications
http://www.soilsforsalmon.org/how.htm
Choosing a Soil Amendment
http://www.ext.colostate.edu/pubs/Garden/07235.html
Compost Effect on Water Retention and Native Plant Establishment on a Construction Embankment
http://ars.usda.gov/research/publications/publications.htm?seq_no_115=187864
Landscape Architect Specifications for Compost Use
http://compostingcouncil.org/seal-of-testing-assurance/

Please visit www.compostsolution.org for many more references on the use of compost for increasing soil organic matter and water conservation.

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