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Composting Grass Seed Straw

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There are many methods and kinds of equipment for composting various materials. Unfortunately, few of these processes specifically address the unique problems of farm-scale composting of straw.

This publication addresses these problems and provides basic information about options for composting grass seed straw. This information is based on 3 years of field trials and research.

There is no one best method of composting straw. This publication evaluates several alternatives and explains some practical rules of thumb for successful composting.

Additional research is needed to assess long-term economic costs and agronomic benefits, and to further refine techniques and equipment.

Why compost?

- Composting is an alternative to field burning and stack burning as a method of managing grass straw.
- Composting can substantially reduce the volume of straw.
- Composting allows you to dispose of straw at relatively little cost, independent of straw markets.
- The finished compost can be used as a soil conditioner.

Figure 1.—*Turning a grass straw windrow using a tractor-mounted compost turner.*

Management options

There are two types of crop residue: (1) the full straw load of "long straw" left after combining, and (2) the residue remaining after removing the long straw, known as "short straw."

You'll need to decide whether you want to compost the full straw load or to bale the long straw and compost only the short straw. It generally takes longer to compost a full straw load, and the resulting product typically is lower quality.

You'll also need to decide what you want to achieve by composting. For example, your primary goal may be straw disposal. Composting can reduce volume by around 90 percent.

Another reason to compost is to produce a soil amendment. The finished compost could be spread back on the field each year.

The cost of composting varies considerably with the method used and the intended use of the compost. Composting costs can range from as low as $15 per acre to more than $30 per acre.

Composting for volume reduction alone allows for the least-cost methods, particularly if you can wait 12 months or more. Composting for a quality product or in less

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Figure 2.—*Using a ground-driven wheel rake to clear a field of its full straw load.*

time requires more attention and energy, and higher costs.

About 1 percent of a field's acreage is needed to compost a full straw load, while only 0.2 percent is needed to compost the stubble residue from a vacuum-swept field. Since composting can reduce volume by up to 90 percent, you can use the same area for composting each year.

The process of straw composting

In broad terms, composting is the biological breakdown of organic material to humus. More specifically, it's a human activity that speeds up this natural process by improving conditions for decomposition.

Composting occurs when microorganisms consume the carbohydrates in plant materials. There are four stages of decomposition, which progress naturally with seasonal changes in precipitation and temperature:

- Stage 1: Moisture content increases.
- Stage 2: The most readily consumable part of the straw is biodegraded in a period of "cooking."
- Stage 3: The more durable parts of the straw (lignocellulose) are broken down. At this point, the straw changes texture and darkens, and volume reduction occurs rapidly and dramatically with turning.
- Stage 4: The compost "cures," or stabilizes to a humic product with a minimum carbon-to-nitrogen ratio.

The most common way to judge the state of degradation of compost is by the carbon-to-nitrogen ratio. Finished straw compost attains C:N ratios of between 10:1 to 20:1, with the carbon fraction reduced from 50–55 percent to 20–30 percent.

How quickly composting proceeds depends on several critical factors:

- Aeration
- Temperature in the windrow or stack
- Moisture content
- Nutrient ingredients of the raw material
- Particle size

Aeration

"Rapid-rate" composting is an aerobic process, which means oxygen is required. Bacteria use oxygen to break down the carbohydrate portion of the straw, releasing carbon dioxide as a byproduct.

Aerobic decomposition takes place on particle surfaces, within the liquid layer surrounding the particle. It depends on the availability of oxygen around the surface of the particle.

Maintaining adequate oxygen is an important part of efficient composting. Particle size, moisture, and natural settling all affect the availability of oxygen.

Temperature in the windrow or stack

Heat is generated as microbes digest the organic matter. The simplest indicator of how well a compost windrow or stack is composting is its internal temperature. Generally speaking, the higher the straw temperature, the more rapid the composting.

Temperatures can range from around 90–160°F in an active stack or windrow. Temperatures above 170°F are not desirable; at such high temperatures, microbial activity is inhibited. The preferred temperature is between 120–150°F.

A dial thermometer with a 2- to 3-foot stem and a pointed tip is handy for checking temperature. You can find these thermometers in lawn and garden sections of many retailers.

Moisture content

For the most active composting, moisture content must be greater than 50 percent, and a range of 60 to 70 percent is preferred. Initially, straw residues contain only 10 to 15 percent moisture.

Rainfall is the most economical way to add moisture. It takes 3 to 4 inches of accumulated rainfall to appreciably increase the moisture content of windrows or stacks.

Nutrient ingredients of the raw material

A C:N ratio of 25:1 to 30:1 generally is considered ideal to commence active composting. Dry grass straw has C:N ratios in excess of 60:1 to 70:1.

Particle size

A particle decomposes and shrinks as microorganisms work their way inward. Smaller particle sizes provide greater surface area, and hence faster rates of aerobic decomposition. You can decrease particle size, thus speeding up composting, by chopping the straw.

Difficulties of composting straw

Straw is good for composting with materials high in nitrogen and moisture content, such as livestock manure and municipal sludge, because it serves as a bulking agent and carbon source. Composting only straw, however, poses unique problems.

Straw can take years to decompose naturally. Even after heat and moisture build up in a windrow or stack, there is little apparent disintegration of the straw for some time.

Two main reasons for the slow decomposition rate of undisturbed straw are (1) its ability to shed rather than absorb water, and (2) its initial high C:N ratio.

Both properties are largely due to straw's high lignocellulose content. Lignin and cellulose are materials that form the woody cell walls of plants and the strong material between the walls. These materials do not break down easily.

The long lag before noticeable decomposition occurs reflects the gradual breakdown of the resistant lignin and cellulose components. Although many bacteria generate heat, fungi and bacteria called actinomycetes are most instrumental in breaking down the lignin. Only after these microorganisms become active does the straw begin to change appearance. Eventually, a threshold of decomposition is crossed, and the proportion of organic matter to total solids steadily declines.

Turning—helping the process along

A stack or windrow of field residues must be "worked" in order to overcome these constraints. Working a compost pile means periodically turning and mixing the material.

By working the compost, you can exercise some control over oxygen, temperature, moisture content, and particle size. As a result, you can reduce the composting time to 5 or 6 months under the best conditions.

The primary reason to begin turning compost piles is to mix wet surface material into the interior. Eventually, it's possible to get the material saturated, with moisture contents of 80 to 90 percent.

Once the straw is saturated, however, you must continue turning the pile to keep oxygen available. By fluffing up settled material, you expose particle surfaces to air and recharge the air spaces in a stack.

Without frequent turning to promote evaporation, dry out the material, and replenish the oxygen supply, it's difficult to sustain aerobic composting. Without adequate oxygen, saturated straw compost continues to decompose slowly; however, anaerobic conditions lead to offensive odors and poor quality compost.

Turning equipment

There are many types of compost-turning equipment. The most effective turners for straw composting have rototiller-like rotors with knives that chop the straw.

The size of the rotor and horsepower of the machine dictate how deep a bite into the windrow a turner can handle. Most turning machines handle windrows that are 5 to 6 feet deep and 12 to 16 feet wide. Self-propelled straddle turners mix the compost in a single pass. Tractor-drawn turners usually extend 6 to 8 feet into a windrow and require a pass up and back to mix both sides of a windrow.

You also can use a front-end loader for turning. Front-end loaders are an economical alternative, as most farm operations have one, and experienced operators can mix and turn stacks fairly efficiently. However, they are not as effective as rotor-type turners, so they require more turnings to achieve a comparable product.

Figure 3.—*Turning a composting straw pile with a front-end loader.*

Composting techniques

Methods for composting grass straw differ according to the grower's objectives. Techniques and costs vary by how you prioritize the objectives of:

- Achieving volume reduction with a minimum amount of effort
- Producing an optimum-quality compost
- Composting in a minimum amount of time

For most growers, the primary goal is to compost for maximum volume reduction with a minimum input of labor and energy.

Alternative methods of composting both long straw and short straw are discussed below.

Figure 4.—*Using a tractor-mounted buck rake to form long straw windrows.*

Long straw composting

Composting a field's full straw load poses a material handling challenge. The most efficient way to gather the straw is to use a large, needle-nose wheel rake to form windrows, and then to push the windrows into a large windrow or stack with a buck rake. However, the stacks present difficulties for rapid-rate composting.

The first problem is the size of the stacks, which can reach 14 to 18 feet high, with diameters of 50 to 100 feet or more. It's difficult to initiate composting in such large stacks, and they are formidable to thoroughly mix. Leaving the straw in windrows makes it easier to reach the interior and avoids the hazards posed by driving machinery onto massive, unstable, slippery, decomposing hills of straw.

The other major problem with long straw stacks is poor moisture absorption due to particle size and too much free air space.

The best solution is to chop or grind the straw to reduce particle size. This can be accomplished by a variety of equipment. For example, some people leave the straw in windrows and use a large, straddle-type compost turner. By the third or fourth turning, the long straw is chopped finely enough to compost as readily as short straw (flail-vac material).

Minimal cost method—slow volume reduction; poor quality compost

Equipment needed: Front-end loader, wheel rake, and buck rake

Time needed: 1 year

To begin:

- Rake and buck straw into stacks.
- Don't build stacks more than 12 to 14 feet deep.

Stage 1:

- After at least 4 inches of rain, compact the stack to 3–4 feet deep, thus immediately achieving a 66 to 75 percent volume reduction. Temperature will increase for a week or so, then cool down to 80–90°F.
- After compaction, you can forget about the stack. Water from precipitation eventually will work its way below the surface, saturating the straw. Let the stack ferment all winter and spring.

Stage 2:

- In late spring, when the site is still accessible prior to harvest, consolidate and restack the material to an 8- to 10-foot-deep pile. The stack should heat up and start aerobic composting.
- After harvest, buck the next stack onto the site, leaving the old compost at the core or mixing it in with the new.

Stages 3 and 4:

- The saturated straw will only partially degrade by fermentation, but it will lose its integrity. It will break up further by mechanical agitation from mixing or spreading.

Higher cost method—quicker volume reduction; fair quality compost

Equipment needed: Front-end loader or a compost turner that chops and turns, wheel rake, and buck rake

Time needed: 6 to 9 months

To begin:

- Rake and buck straw into windrows or multiple stacks.
- Don't build stacks more than 12 to 14 feet deep.

Stage 1:

- After at least 4 inches of rain, turn the windrow or stacks and work them to 6–8 feet deep. Some soil scraped and mixed in is beneficial.
- Monitor the temperature in the windrow or stack.

Stage 2:

- Turn the windrow or stacks during winter and early spring whenever the straw temperature is less than 115°F. You probably will need to turn them every 6 to 8 weeks after the first mixing.

Stage 3:
- Continue turning. Each turning should result in less area than before.
- Turn and consolidate the material after April. Don't bother with further mixing unless the straw temperature drops below 90°F.
- The material should get darker after each turning. With warmer spring weather, mushroom growth should be widespread. The material will maintain its long straw appearance, but will lose toughness with each turning after fungi appear.

Stage 4:
- By the following harvest, the material should be fairly dark and easily broken up by mechanical agitation.
- Buck the next stack onto the site, leaving the old compost at the core, or mixing it in with the new.

Short straw composting

If you remove the long straw by baling, and use a "flail-vac" and stack wagon system to further clean the field, you'll end up with material that composts fairly easily. This mix of flailed stubble, vacuumed chaff, and loose soil readily composts once it's wet enough and is turned several times.

Empty the stack wagon's load into a row of loaves to form a windrow. Prior to the start of fall rainy weather, tip the loaves over on their sides. This greatly improves water infiltration and shortens the height of the windrow for turning equipment.

This system has several advantages. Flailing breaks the straw into smaller particles, exposes interior surfaces, and produces a more water-absorbent material. In fact, about 20 percent of flail-vac material is fine enough to be considered soil, and another 3 to 4 percent is seed. The mixed-in soil also absorbs water and inoculates the windrow with soil-borne microorganisms. Initial C:N ratios of flail-vac material range from 40:1 to 50:1.

When well managed, flail-vac composting can yield an excellent, attractive peat-like product. If left unused, the material continues to cure and degrade until it virtually disappears.

Figure 5.—*Forming a short straw windrow with a flail-vac and stack wagon.*

The following two methods can be used to compost flail-vac material.

Minimal cost method—slow volume reduction; fair quality compost

Equipment needed: Front-end loader or a compost turning machine

Time needed: 6 to 9 months

To begin:
- Flail-vac the field, and form windrows post-harvest in July/August.

Stage 1:
- Tip the loaves over on their sides with a front-end loader in late summer or early fall prior to November rains.
- Turn the windrow after 3 to 4 inches of rain falls (hopefully before Thanksgiving). The windrow will heat up, then gradually cool off. Heavy rains and melting snow lead to settling and loss of free air space.
- Let the windrow sit through January.

Stage 2:
- Turn again when the site is accessible in February or March.

Stage 3:
- Do a third turning after more rain falls and the straw temperature drops below 90–100°F.
- The straw volume probably will be reduced by 70 to 80 percent.

Stage 4:
- The straw will not be fully degraded; it will be a mixture of dark and light organic matter.
- Build a new windrow next to the composted one to avoid getting stuck in old, wet material.
- After tipping the new windrow, use a loader or scraper to combine the old compost with the new material.

Figure 6.—*Using a straddle-type compost turner on a short-straw windrow that is composting.*

Higher cost method—rapid volume reduction; good quality compost

Equipment needed: Compost turner (using a front-end loader for this many turnings could form ruts in muddy ground)

Time needed: 6 to 9 months

To begin:
- Flail-vac the field, and form windrows post-harvest in July/August.

Stage 1:
- Turn the windrow after 3 to 4 inches of rain falls.
- Measure the straw temperature periodically.
- Turn again after the straw temperature drops below 115°F and the field is accessible, probably before New Year's.

Stage 2:
- Do a third turning in late January or early February as field conditions and weather permit.

Stage 3:
- Do a fourth turning around early March. Continue turning every week or every other week until the windrow or stack temperature no longer rises above 120°F.
- You should have 90 percent volume reduction and a dark, peat-like compost by May. The compost possibly could be done as early as the end of March.

Stage 4:
- The material will continue to cure until it's spread over the field.

Composting economics

Cost

The cost of composting depends on how much you manipulate conditions in the windrow or stack (oxygen, temperature, moisture, and particle size), primarily by turning and chopping.

Total costs for flail-vac windrow composting (including residue collection, stack preparation, and turnings) range from around $24 per acre to over $31 per acre. The flail-vac operation alone accounts for $20–$22 per acre of these costs.

Total costs for full straw load composting range from $15 per acre to over $25 per acre. The raking operation alone accounts for $13–$15 per acre of these costs.

These values are estimates based on field trial observations and farmer interviews. Of course, actual costs vary with machinery, operator, weather, and field conditions.

Benefits

The value of compost lies in its ability to release nutrients over a long period of time, return organic matter to the soil, and improve soil tilth. Because these factors cannot easily be assigned a dollar value, they generally are termed intangible benefits.

Table 1.—*Nutrient content of compost.*

Stack	N lb/ton	P lb/ton	K lb/ton	Ca lb/ton	Mg lb/ton
short straw	31.8	0.53	17.3	8.2	2.0
short straw	36.2	0.75	17.6	9.5	3.1
short straw	45.2	0.88	25.5	6.4	3.4
long straw	32.2	0.86	35.1	3.2	2.9
long straw	27.6	0.18	14.6	4.2	1.2

The nutrient levels in compost typically are low when compared with synthetic fertilizers. Table 1 presents the approximate nutrient content of three separate compost windrows and two long straw stacks after 7 months of composting.

Table 2 shows an estimate of grass straw compost's economic worth on the basis of its nutrient reclamation value. The compost dollar value is about $14.50 per dry ton if we assume an average straw compost nutrient value as shown in Table 2.

Figure 7.—*Remains of two 8-foot-deep straw windrows composted practically down to soil.*

Additional recommendations and alternatives

- For easy access, place windrows and stacks near a gate on the driest ground available.
- Prepare and turn the windrow or stacks during periods of rainy weather when possible.
- Place windrow or stacks near areas of poor soil fertility, and spread the compost there.
- Use a hydrostatic drive tractor with PTO-powered windrow turners to allow maximum power output at very slow ground speeds.
- If you plan to continue composting, consider installing a small irrigation system (garden-scale gpm hoses and sprinklers) to get a head start on watering stacks in summer and early fall. Hauling water to sites is cost-prohibitive.
- Compost straw with livestock manure-slurries or municipal sludges; there may be opportunity for income in disposal tipping fees.
- Contract with a custom operator to manage turning operations. This spreads out the cost of equipment over more acres and usage, resulting in lower hourly operating costs.

Table 2.—*Dollar value of nutrients in compost.*

	N	P	K	Ca	Mg
Nutrient content	1.73%	0.03%	1.10%	0.32%	0.13%
Fertilizer cost/lb	$0.24	$1.47	$0.22	$0.05	$0.05
Nutrient value/ton	$8.31	$0.88	$4.75	$0.32	$0.13
Total value/ton					$14.39

For more information

The On-Farm Composting Handbook, Publication NRAES-54 (Cornell University, Ithaca, NY), 186 pages, $15. Available from the Northeast Regional Agricultural Engineering Service Cooperative Extension, NRAES/FC, 152 Riley-Robb Hall, Cooperative Extension, Ithaca, NY 14853-5701.

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