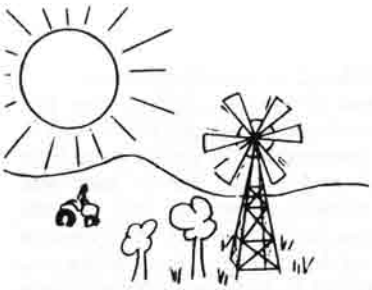


PROJECT FOCUS #8

Small Farm Energy Project

Composting of Farm Manure

JANUARY, 1980

"Project Focus" is part of a primer on energy alternatives that would help lower the high costs of energy inputs on small farms. The examples are drawn from innovations built by northeast Nebraska farmers who are participants in the Small Farm Energy Project, a special 3-year research effort sponsored by the Center for Rural Affairs of Walthill, Nebraska and based in Hartington, Nebraska. The aim of Project Focus is to help small farmers discover and develop viable alternatives for their own farms.

Sir Albert Howard utilized the composting process in India decades ago. He developed the technique to assist impoverished farmers increase soil fertility by making better use of organic wastes. Now a popular gardening technique and a waste disposal alternative for municipalities and large feedlots, composting has been slowly receiving greater attention as a valuable tool for the family livestock farm. Although composting of farm manures requires time and energy, which is difficult to measure, researchers have found a wide range of benefits in the composting process. The unique feature of composting is its biological process, which is completely different from the conventional N,P,K approach to soil fertility. As energy and commercial fertilizer costs continue to rise, composting will more than likely become more important in the future.

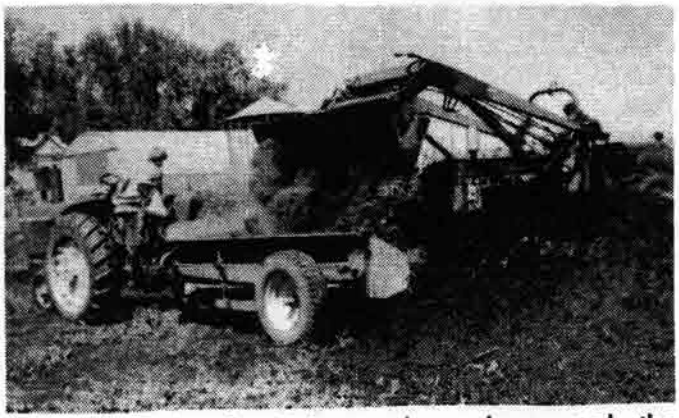
Managing Manure As A Resource

After learning of the relationship of rising energy costs to higher commercial fertilizer prices, cooperators of the Energy Project have considered various alternatives of lowering commerical fertilizer purchases. **Nitrogen fertilizers, in particular, require large amounts of natural gas during production. One alternative has been to better manage livestock manure, and thereby make better use of nutrients available in manures.**

Conventional Manure Handling

Conventional manure handling practices include the spreading of manure onto fields whenever convenient for the farmer. Often these times are during wet or frozen soil conditions, which do not allow the farmer to incorporate the nutrients into the soil to avoid leaching and volatilization of nutrients, particularly nitrogen. USDA figures indicate that **50-75% of the nitrogen can be lost during conventional manure handling,** with 25% lost within 4 days of field application.

Composting As An Alternative



—Phil and Mike Heimes, above, have used the "loader-spreader" method of compost turning. Although the method involves extra handling time, it makes use of common equipment most farmers already have.

—Edgar Wuebben, left, records temperature readings of his windrows of compost. Although composting is difficult to analyze, Wuebben is pleased with the results of using composted dairy manure in place of commercial fertilizers. Compost is the result of a biological process and a completely different nutrient source than the conventional N,P, and K approach to fertility.

Composting has been attempted by cooperators of the Energy Project as a manure management tool. Of the nearly 10 farms that began composting three years ago, four have continued their efforts yielding considerable information about the process. **Composting, basically, is a controlled microbial decomposition of livestock, crop and other residues.**

Composting, like many other energy conservation alternatives, is **"site specific."** Some farms can more easily adapt the process than others. Hog farmers in Cedar Co., for example, have low volumes of manure compared to dairy operations, making composting less "time effective" for swine enterprises. However, **where composting is not utilized, raw manures are best incorporated into the soil to conserve nutrients.**

Prior to composting, manures removed from livestock yards during winter and spring are piled in windrows at the end of a field and near the farmstead to minimize hauling costs.

The windrows are usually about 4 to 5 ft. high and from 8 to 12 ft. wide at the base, with about a 2 ft. flat top, and they are formed with a P.T.O. driven manure spreader, moving slowly forward to form the windrow. The beaters of the spreader break up and aerate the manure, blending bedding and crop residue with the manure. The composting process can begin immediately if conditions of moisture, temperatures and carbon content are proper.

Later compost windrows are "turned" to "aerate" the material.

The Composting Process

Decomposition by Aerobic Bacteria

In composting of manure and crop residue, the material is "aerated" by turning the piles, thereby incorporating oxygen into the pile. **Tiny microbes, bacteria and other organisms use the oxygen to consume the waste material.** Carbon dioxide, water vapor and heat are given off, just as in other biological activities.

Dr. Dan Dindal, soil ecologist from State University, Syracuse, N.Y., spoke to cooperators of the Energy Project on composting. He suggests that **organisms in the compost take various nutrients into their body tissue.** "They merely hold them in tiny banks to avoid leaching," Dindal explains, "until the nutrients are required by plants in the soil."

During composting, temperatures can exceed 150 degrees F. within the compost pile, as various organisms do their work. However, **temperatures should not be allowed to exceed 150 degrees,** notes Leon Chesnin, soil chemist at the U. of Nebraska. Higher temperatures will cause ammonia losses, which can be reduced by turning at the times of the higher temperature levels. However, researchers point out that nitrogen losses will always occur to a certain extent in composting. Dr. Hardy Vogtmann, a Swiss researcher, suggests losses can be 30% for nitrogen.

Moisture and Carbon Content Important

Optimum moisture content for composting manures is near 60% or about like that of silage. **Carbon-nitrogen ratios of between 20 and 30 to 1 are also recommended. Additions of straw bedding or crop residues provide for both carbon and moisture levels near the optimum ranges.** In their first composting efforts, cooperators of the Energy Project often had very wet manure, low in carbon content, that was difficult to compost. Edgar Wuebben and his two sons, Don and Terry, corrected the difficulty by using large quantities of straw bedding in the yards of the dairy herd, which also utilizes the residue for feed. Manure from a loafing barn is also scraped periodically and mixed with straw and other manure before being placed in windrows. Straw is harvested from stubble fields in late summer after the oats crop is chopped for silage. Corn stover is also being considered as a carbon source.

Bob Steffen, a farmer and Cedar Co. native, who has studied composting for several decades, suggests that with a low carbon to nitrogen ratio, composting requires more time and turning due to lack of air and usually due to very wet conditions. "The low carbon content, of course, will provide insufficient food for the nitrogen loving bacteria to reproduce fast enough in order to handle all the nitrogen," Steffen reports. "That is why a manure pile without bedding will always have a stronger ammonia odor than one with enough bedding. The nitrogen is escaping as a gas." Steffen also has a rule of thumb for checking carbon content when "stacking" piles 4 or 5 ft. high: "If it won't stack up you need more bedding material." H.H. Koepf, a German soil scientist, suggests additions of 5-15 lb. of bedding to livestock areas for every 1000 lb. of animal weight on a daily basis.

Compost Turning

Cooperators of the Energy Project process manure in the composting operation during late summer months. Farmers find extra time during August for composting, between the busy planting and harvesting seasons. The compost is "turned" once a week for four weeks using various types of equipment. Compost is usually "finished" when the compost cools to under 100 degrees and no ammonia odors are evident. **Although August may be convenient for composting, it is always best to compost the stockpiled manures as soon as possible,** to avoid nutrient losses, particularly ammonia. Initial results of Energy Project studies seem to indicate that **considerable nutrients can be lost from livestock yards and windrows before composting begins.** Manure upon leaving an animal can have over 5% N, which can be reduced to much less than 1% with delayed and improper handling. Chesnin reports, "Fresh beef cattle manure has about 3.5 per cent nitrogen. A considerable amount of this nutrient can be lost if the waste is not managed properly. Composting under controlled conditions will conserve and concentrate the nitrogen in the manure." **However, time and energy inputs into the compost process should be minimized to hold processing costs down.**

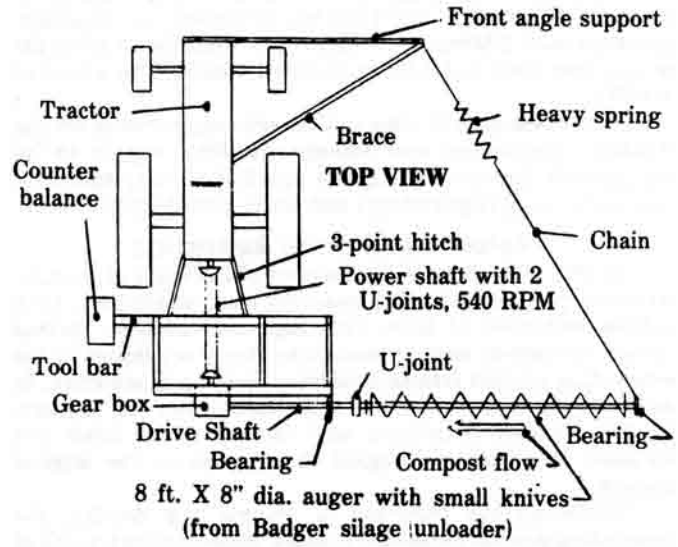
Composting Equipment

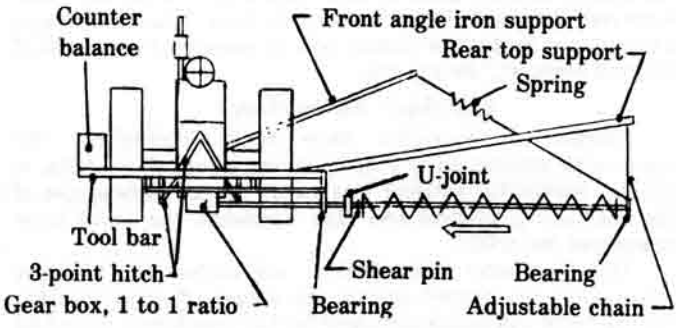
—Edgar Wuebben built his own compost turning machine entirely from old equipment on the farm. An old tool bar, gear box, and silage auger make the major components. The auger on the right opens up the compost windrow, aerating the material. Later a front-end loader repiles the windrow.

—The home-built compost turner constructed by Bill and Martin Kleinschmit from an old windrower. The system straddles the manure windrow in the compost "turning" process. A 9 ft. wide by 24" diameter rotating drum replaces the cutting head of the windrower. Hydraulic power is used for the ground drive and slow forward motion.

(continued on page 37)

Wuebben Home-Built Compost Turner

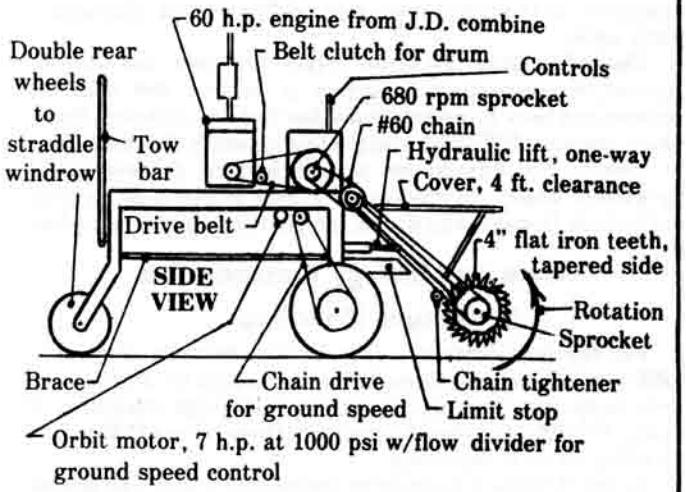


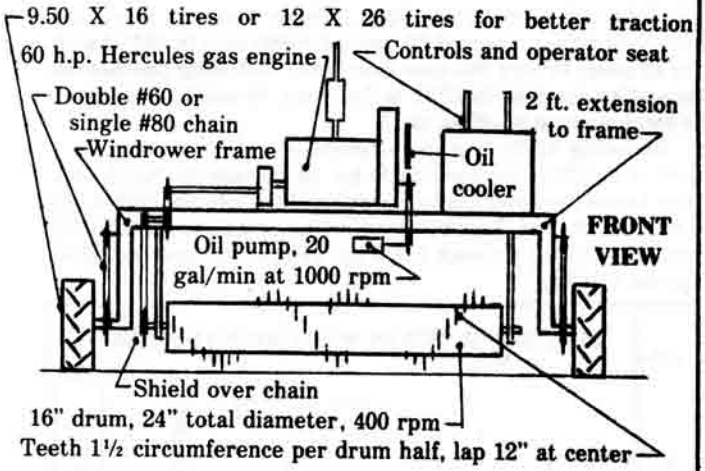


REAR VIEW

NOTE: PTO shaft should be long enough to allow raising & lowering of system by 3-point hitch

Kleinschmit Home-Built Compost Turner





Home-built Compost Turners

Edgar Wuebben built his own compost-turning device from discarded materials at the farm, including a gear box, tool bar and silage unloading auger. The device is mounted to the tractor by a 3-point hitch and is driven by the P.T.O., as the small tractor "idles" down the pile. The process takes about six passes down both sides of the compost windrow, "opening" the pile and spreading the pile out over the soil. After the aeration, a tractor front-end loader is used to repile the material.

Bill Kleinschmit, another cooperator of the Energy Project, **has used a home-built turner constructed from a used forage crop windrower and other materials** for just over $1100. The turner straddles 4 ft. X 8 ft. compost windrows. A rotating drum with flat iron teeth replaces the cutting head of the conventional windrower and is driven by a roller chain from the 60 h.p. engine. The drum lifts the material up and toward the rear of the turner, and can be raised or lowered by hydraulic cylinders. The turner uses a hydraulic pump, orbit motor and flow control valve for the ground drive to obtain slow forward motion, although much of the drive assembly is the same as used by the original windrower. The frame of the windrower was also raised to a level 2 ft. higher above the ground, in order to straddle the four foot high windrows. Kleinschmit uses a belt and chain drive for the drum rotation, but recommends a hydraulic drive to avoid problems with chains near the windrow, although that would require more power and a larger cooling device for hydraulic fluid.

Loader-Spreader Method

A common procedure for composting used by many farmers is the **use of the manure spreader and front-end loader,** commonly available to most farmers. The manure, after it is in a windrow, is loaded back onto the spreader with the loader and passed through the spreader into another parallel windrow, aerating and mixing the material so that organisms can process the material effectively. Mike Heimes, also an Energy Project cooperator, used the loader-spreader method in 1977, turning compost four times. However, Heimes has found that the great amount of time required by this method is a disadvantage to composting. During 1979, he used the commerical "Easy Over" composter to speed up the operation.

Commercial Composter Saves Time

In 1978, the Wuebben's acquired the "Easy Over" commercial composting machine. The machine costs over $4000 but is capable of processing 400 to 500 tons of compost per hour. Therefore, it can save time in composting, although it requires a larger tractor with at least 100 h.p. The machine resembles a large garden tiller, which lifts the material up and back into the windrow, aerating one-half of the windrow with each pass of the machine. A tractor with hydrostatic drive is preferred for slowest possible ground speed. The machine can be towed easily over county roads for custom services. The Wuebben's have also rented the device to farmers, including Mike Heimes.

Energy, Labor and Nutrient Considerations

Extensive experience has been gained by Energy Project cooperators in the compost process, yielding much information on the topic.

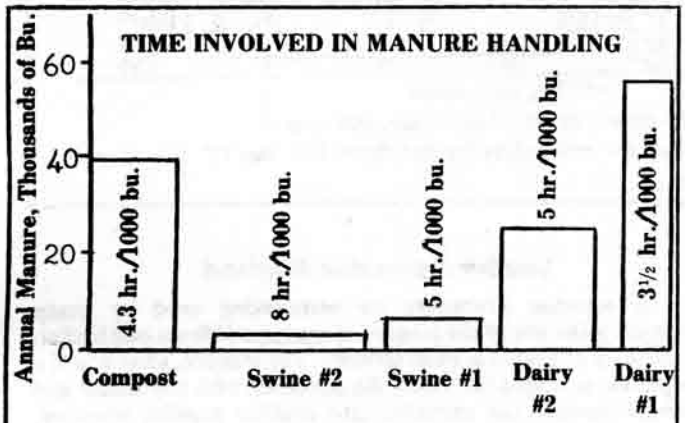
The information gathered relates to time and energy required in composting, reduction in volume and mass of manures, nutrient retention, and other factors. Although **these factors are very difficult to analyze** and although the results are not precise, the information is sufficient to develop initial impressions about the process. The data is based on records kept by four farmers who do not compost and two farmers who do.

Time and Energy Consumption in Manure Handling

For the hog producers with limited volumes of manure (3,000 to 6,000 bu./yr.), three days were enough to clear out the yards in spring. But dairy operators with large quantities of manure (25,000 to 55,000 bu.) required three weeks (130 hours) of hauling to clear the yards.

In the Wuebben composting operation, it took two people an equivalent of one week to haul manure to the windrow in 1978 and an equivalent amount of time to haul finished compost from the windrow to the field. Three turnings with the home-built auger required 30 hours for 300 tons **in 1977** but **it took 12 hours to turn 600 tons four times with their commercial composting machine in 1978, or between 10 and 15 percent of the total manure handling time.**

Reducing all figures to comparative units, it took 5 to 8 hours of handling for each 1,000 bu. of manure on hog farms. Dairy farms required 2½ to 5 hours of handling for each 1,000 bu. of manure. The Wuebben composting operation required 4.3 hours of handling for each 1,000 bu. of raw manure, including compost turning.



1978 FARM TIME AND ENERGY RECORDS

Farm	Total loads	Spreader cap., bu.	Loads/hour	Total Volume, bu.	Total hours	Hours/1000 bu.	MBtu/1000 bu.	Total gas use, gal.
Dairy #1	280	150	2.1	56,000	130	2.5	.4	127
Dairy #2	160	160	1.2	26,000	130	5	1.1	230
Swine #1	100	60	3.6	6,000	28	5	1.3	62
Swine #2	42	75	1.7	3,000	25	8	2.1	53
Compost #1	260	150	3.2	39,000	80	2	.2	
Turnings					12	.3	.3	
Application	200	150	2.5	30,000	80	2	.3	
Compost Total					172	4.3	.8	220

Energy requirements paralleled patterns of the labor requirements. The hog operations used from 1.3 to 2.1 MBtu for each 1,000 bu. hauled. Dairy farmers used from .4 to 1.3 MBtu for each 1,000 bu. For each 1,000 bu. of manure, the Wuebben operation used .2 MBtu for hauling to the windrow, .3 MBtu for turning four times and .3 MBtu hauling to the field for a total of .8 MBtu.

From these figures, time and energy requirements for the Wuebben composting and manure handling appear to be intermediate between the highest and lowest dairy operation time and energy requirements and lower than hog operations.

Volume and Mass Reduction

In 1978, Wuebben made windrows of 260 loads of manure. After composting, he hauled away 200 loads of compost, for **a volume reduction of 25%.** This happened because various carbon compounds were consumed by decay organisms in the composting process releasing carbon dioxide and moisture. In addition, the compost became less dense than the manure. Similar volumes of manure and compost were dried and weighed. **The compost weighed ½ as much as the original manure.**

Combining the reduction in volume and density, **the composting process reduced the entire mass [weight] to 3/8 of the original manure mass.** Chesnin at the U. of Nebr. has noted mass reduction up to 1/6 of the original mass. "On the average, 4 to 6 tons of beef cattle manure will be converted to one ton of finished compost," he reports.

Nutrient Retention

Samples of nutrients were taken throughout the composting process on two dairy farms. From the results, it appears **substantial nutrient loss occurs during early stages of the composting process and that nutrients can leach from composted materials.**

Organic matter content (OM) and carbon to nitrogen ratios (C:N) are plotted against the stages of compost (first, second, third and fourth turnings) for the two farms. Both OM and C:N are indicators of the proportion of organic material to mineral content. Both measures are based on dry weight. An increase in organic matter content means a relative decrease in mineral content.

Results from the Wuebben farm (A) demonstrate the expected patterns in figures 1 & 2 with OM content and C:N ratios declining as the decay organisms consume the available carbohydrates. Results from the Heimes windrow fit the pattern up to the third and final turnings. OM content and C:N ratios double. It is unlikely the increase was caused by production of carbon and organic matter in the midst of a decay process. The dramatic change is more likely **the result of nutrients leaching during heavy rains** (4" to 5") which occurred during the week of October 15th after the last Wuebben sample was taken, but three weeks before the final Heimes sample was taken. **A 1978 compost sample stored by Wuebben for a year also showed low nutrients after one year.**

Nitrogen content is plotted against the composting process in figure 3 indicating fairly consistent levels for the Wuebben operation but substantial decline in nitrogen for the Heimes farm (B) after the second turning. Because this figure doesn't take into account the reduction in mass during the composting process, in figure 4 is presented nitrogen content relative to the nutrients in the manure at initial phases of the composting process. In the Wuebben case, 20% of the original nitrogen after the first turning was retained while the Heimes operation retained from 10 to 15%, based on constant mineral content.

Techniques which may prevent this nutrient loss include covering the windrow to prevent ammonification and leaching, greater use of straw to absorb liquid nutrients, early turning after windrowing in the spring, and prompt field applications of the finished compost. Further research would be valuable to confirm some of the initial results of Energy Project studies and to find ways of improving nutrient and energy conservation.

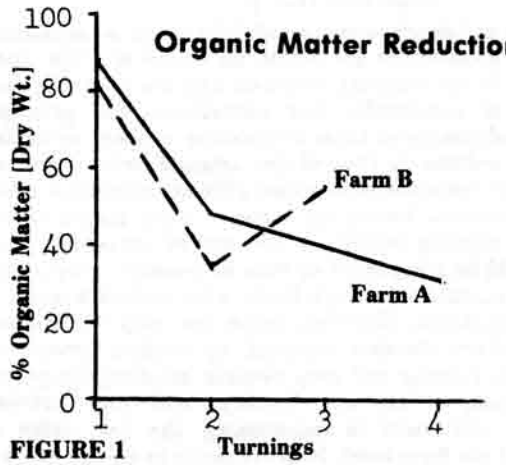


FIGURE 1

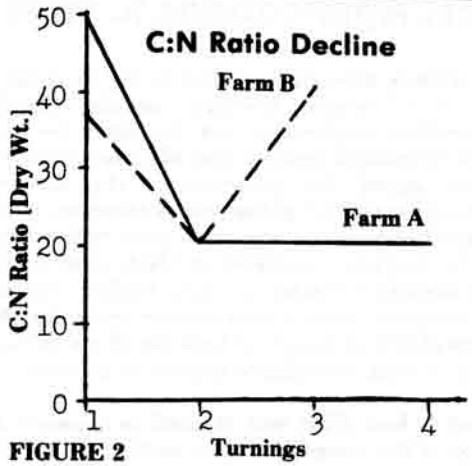


FIGURE 2

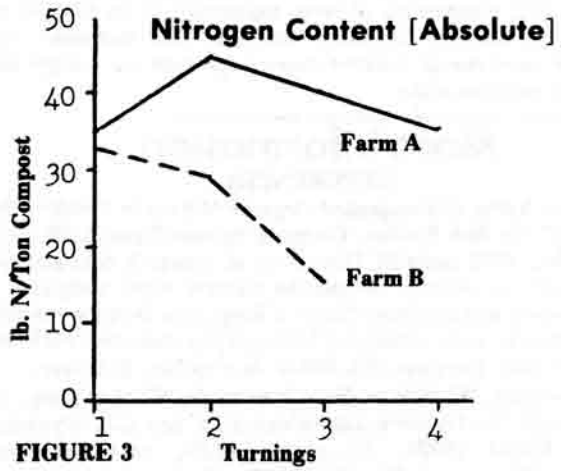


FIGURE 3

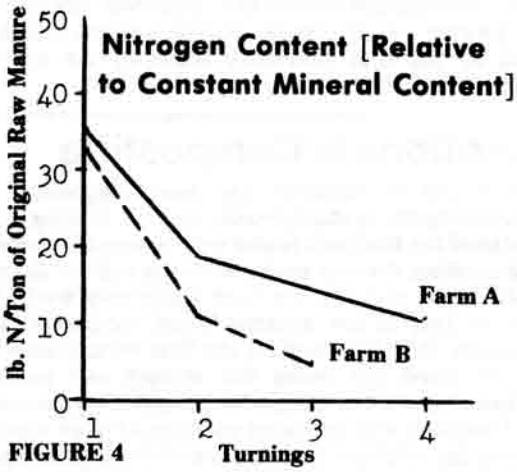


FIGURE 4

Advantages of Composting

Variety of Benefits

Although nutrient conservation was thought to be a major advantage of composting, preliminary studies have shown otherwise, as indicated previously. It may be possible to improve the various nutrient factors by utilizing more care and timeliness in the process. However, it should be emphasized that **N,P, and K nutrients probably comprise only a small portion of the many benefits that farmers can realize from the composting process.**

Heat is generated in the compost piles by the micro-organisms up to temperatures of 150 degrees. Such **temperatures can destroy the germination potential of weed seeds** in manures and crop residue. Edgar Wuebben sees better weed control without herbicides as another plus in composting. The high temperatures can also help to control flies.

Researchers have found that **compost improves the tilth of the soil, its resistance to erosion, and the soil's capacity to hold water for plant growth,** thereby requiring less rainfall or irrigation for productive crop growth. **Compost can also improve the availability of plant nutrients,** both in the compost and in the soil to which compost is added. Phosphates, for example, can be added to manures during composting, making the mineral more available to plants, especially in soils where such minerals are often "tied up" and not made available to plants.

Bob Steffen states, **"The most significant contribution made by the composting process is its long term effect on soil fertility, especially on accumulated fertility."** Steffen has followed European researchers in their studies of farm composting, which appear to be more advanced than that of the U.S. Steffen notes that the German H.H. Koepf has found that raw manures will stimulate biological activity in the soil, but only for short periods. "Composted material, on the other hand," Steffen reports, "not only stimulates these biological processes, but also enhances the supply of accumulated fertility, which is the real basis of a fertile, productive soil." He further notes that compost encourages root growth, while raw manure can inhibit it. "Improved root growth, in turn, loosens the soil, improves tilth, and adds to the organic matter content."

The Swiss researcher, Hardy Vogtmann, suggests that nitrogen fixing bacteria exist in the compost pile and continue fixation when compost is applied to the field. In addition, he reports that European research indicates composts will include natural antibiotics, hormones and other properties beneficial to plants.

Mass Reduction & Proper Application

Chesnin of the U. of Nebr. indicates that one of the chief benefits of **composting** manures is that it **lowers the costs of hauling manures,** often containing as high as 95% moisture, to fields. "It costs to process, but it costs more to haul water to the field," Chesnin reports. "Fewer trips across the field are required in compost applications.

The over-all reduction in weight and volume also means less total soil compaction. Soil compaction by heavy equipment and the weight of manure can damage the soil structure, lowering productivity, especially during wet soil conditions.

Yields and Fertility Expenses

Compost, when substituted for commerical fertilizer, not only saves money, but also **provides most of the nutrients for productive crop yields.** In the fall of 1977, Edgar Wuebben applied 7 tons of compost per acre to one of his fields. In 1978,

(continued on page 40)

Compost Applications to Soils

Spreading of finely processed compost at low rates can be difficult with some manure spreader models. Modified spinner-type fertilizer applicators can be used for light applications. The Wuebbens process over 600 tons of compost per year. They spread the materials in the fall with conventional manure spreaders at the rate of about seven tons per acre. Such **applications are made every three to four years,** with much of the nutrients available to plants over several years. The late German soil scientist, E.E. Pfeiffer, indicates that most farm composts "have a total nitrogen content of .5 to .7% at a moisture of 50% and more, or between 10 and 15 lbs. of N per ton. Energy Project experience appears to be within this range.

The compost is best tilled into the soil to conserve the bacterial activity of the compost. This is usually done with a chisel plow or a disk. The Wuebbens have also spread the compost onto fields planted to corn as a "sidedress" fertilizer in June when the corn was six inches tall. The compost was then incorporated by the first cultivation following the manure spreader, which straddles the corn rows.

Variations in Composting

LaVern Truby of Randolph has been composting for several years using the loader-spreader method. During 1978, however, he **used the front-end loader only to turn the compost for the final aeration,** thereby saving time and energy. Energy Project staff believe that the front-end loader only method is appropriate, as long as the material is not compacted. The manure spreader should be used for the first several aerating operations, to blend and refine the manure and residue. Europeans have reported on using a feeder-type wagon to make windrows of compost with continual additions of more manure to one side of the windrow and removal of finished compost from the other side. **No turning is used** after the initial aeration when the material is added to the pile. Single windrows have also been used without turning. **However, proper moisture and carbon content are essential** for good composting by this method, and such conditions are often difficult to obtain.

For manure stored in windrows during cold winter months, the piles may be larger and near 9 ft. tall to aid initial composting action and to retain heat, suggests Dr. Leon Chesnin. Some farmers have considered "dumping" the manure into windrows, using special dump wagons to hasten the hauling process. Composting can begin later during the first aeration when convenient. However, the manure spreader is beneficial in mixing and aerating the manure, and making properly shaped piles.

Small additions of soil are recognized as beneficial to composting processes. Adding some mature compost to the process as an "innoculant" is also suggested. **Cooperators of the Energy Project use no commercial bacterial innoculants in composting.** The Wuebbens have found that waste paper and feed sacks make a good addition to the compost. Several people from nearby towns are disposing of waste paper for composting at the Wuebben farm. Paper goods are thoroughly decomposed, converting another waste to a resource.

[Compost Advantages, continued from page 39]

that field yielded an average of 80 bu./acre. The application amounted to 112 lbs. of N, 84 lbs. of P and 161 lbs. of K per acre. That same year Wuebben also spent an average of $13.70/acre for commercial fertilizer on 145 acres of another corn field. The application amounted to 43, 21, and 10 pounds respectively of N,P and K. That corn yielded an average of 71 bu./acre.

Yield comparsions for 1979 are not meaningful because of a late July hailstorm occurring just after the tassling period.

Summary

The time and energy expenses of dairy manure composting and compost applications are within the range of other dairy farmers who do not compost manures, and are relatively less than those of comparable hog operations. **The principal measurable advantage of farm composting appears to be the reduction in volume to 75% of the original volume and an over-all weight reduction to less than 40% of the original mass. Substantial nutrient losses can occur** in early stages of the process and leaching losses are not always prevented. **Raw manure should be composted as soon as possible.** Crop yields appear to be maintained at high levels with moderate levels of compost applications. However, these are only preliminary research findings. **Further research** by various groups on energy use in turning and crop residue handling, long-term effects of compost on soil fertility, and also nutrient conservation **will assist in determining the real value of composting at the farm level.** Improvements in equipment will help to further improve time and energy conservation. But it appears that composting of farm manures can be feasible on farms with sizeable livestock numbers. **The technique will probably continue to become more important as energy and fertilizer costs escalate.**

More Information

REFERENCES

"The Value of Composted Organic Matter in Building Soil Fertility", by Bob Steffen, **Compost Science/Land Utilization,** Sept./Oct., 1979, page 34. Discussion of research data showing the greater benefits of composted manure when compared to raw manure, and the importance of long-term fertility reserves and humus in soils; extensive bibliography included. JG Press, Inc., Box 351, Emmaus, PA 18049, bi-monthly, $15/year.

"Compost, What it is, How it is made, What it does," by H.H. Koepf, Bio-Dynamic Literature, P.O. Box 253, Wyoming, Rhode Island 02898, 18 pages, $1.00, reprinted from **Bio-Dynamics** Issue No. 77, 1966. Basic introduction to composting for farmers and gardeners on the what, why, and how of composting, various inputs to compost piles, carbon-nitrogen ratios, equipment use, micro-organisms, how much to apply and much more. Excellent!

"Biodynamic Composting on the Farm," by Peter Blazer and **"How Much Compost Should We Use?"** by Ehrenfried E. Pfeiffer, a booklet from Biodynamic Literature, Box 253, Wymong, Rhode Island 02898, 23 pages, $1.65. Comments on composting methods and conditions, equipment used, and "further suggestions for composting operations." Includes information on soils, organic matter levels, soil life, compost application rates and affects under various soil conditions.

"Composting Pointers," Small Farm Energy Project, P.O. Box 736, Hartington, NE 68739, 25 cents. A one-page review of suggestions made by Dr. Hardy Vogtmann, Swiss compost expert during his Nebr. visit in May, 1977.

"Composting Converts Waste Into Valuable Resources," by Leon Chesnin, **Farm, Ranch, and Home Quarterly,** Fall, 1977, U. of Nebr., Lincoln, Nebr., page 19. Discusses the value and operations of composting for agricultural and municipal wastes, as well as nutrient and large energy saving resulting from composting various wastes in Nebraska.

"Compost", by C.J. Fenzau, **Acres, U.S.A.**, Dec., 1975, page 8. Fenzau lists "18 merits of pre-digested manure." Includes suggestions on composting and gives activities of compost microorganisms that make it valuable to soils. Also includes some "lab data" and hints on pricing compost.