Community compost containing plastic and other non-degradable debris being spread in French vineyard. (Photo by Woods End Laboratory)

PART I — BASICS OF THE PROCESS

SUSTAINABLE composting IN THE VINEYARD

BY Will Brinton and Alan York

"Compost" is a word with ancient enough roots that its derivation is difficult to trace. The verb "to compost" comes from *componera*, Latin for *to bring together*. By these accounts, recycling organic waste and composting are closely associated to the earliest roots of viticulture.

Today, pressure mounts to recycle ever-larger amounts of waste in ever-smaller or more densely populated regions. There is also growing realization of the senselessness of hauling organic materials to landfills.

Re-energizing of composting raises many questions. These include: When composting was small and sustainable, how did it merge into the natural rhythms of each farming operation? Just how much technology is required to make proper compost? Further, when is compost actually compost? Author Gene Logsdon, writing in *Biocycle* in 1989, said, "In the not-too-distant future, compost making may well be as much an artful science as winemaking." Indeed, when you consider the maturing of plant-growth properties and the increase of natural disease suppressiveness over time in compost, it really can be accurately compared to controlled ageing of wine.

With composting now assuming its role as a vital agricultural activity, new pressures are mounting that threaten to marginalize it as an isolated technological process without any direct roots in farming. An example of the apparent extremes to which modern waste and composting have been driven is agriculturalist Dr. Konrad Schliess's observation after a 10-year survey on the status of composting in Switzerland: "From a functional point of view, it is apparent that the sole purpose of modern composting is to process green waste with a minimum of outlay and get rid of the end product as quickly as possible." (Konrad Schliess 2002-Swiss Agency for Environment, Bern). The analogy of this situation to winemaking would be to go for maximium grape yields and complete minimization of maceration. Composting requires proper time and management to result in a soil- and crop-improving material.

With organic waste issues arising everywhere and recycling increasingly mandated by legislative act, composting has been promoted as an industry unto itself, separated from its original agricultural roots. Now, under often strict authority of solid waste and environmental agencies, composters have come to rely heavily on the "tipping" fees they charge agricultural producers to dispose their waste. Composting facilities have thus become kind of glorified dumps, with the revenues from the sale of their end-product — compost — strictly a secondary concern. This is a very curious development as for farming.

Broadcast-spreading of compost (under 3 tons/acre) at McNab Ranch Vineyard, Ukiah, CA.

We recall the experience of many European vineyards in the early days of large-scale municipal composting in the 1970s and 1980s. Then, soils in the vineyard became contaminated with non-biodegradable residues found in the waste stream, which in turn ended up in compost that was often provided free of charge to growers.

Certainly, French and German growers have learned from the experience of contaminated mixed-waste composts. Our own Woods End Laboratory (Mt Vernon, ME) analyzes compost not only for nutrients but also for specific physical (plastic and glass) content. We use the German limit of 0.5% as a maximum acceptable content. In fact, determined to replace the

Microscopic image of grape seeds which have partially survived 1-year compost cycle. (McNab Ranch/Photo by Woods End Laboratory)

concept of waste with that of compost-product, Woods End Laboratory has launched a quality ranking system that uses a matrix of test parameters to classify compost into six best-use groups. This enables growers to properly select applications, leading to better results. Compost improperly used can be worse than no compost at all.

Clearly, the pressures for processing organic wastes, including in some cases, the levying of financial penalties where recovery rates are not attained, does not directly translate into a quality product for agriculture. That goal is actually determined by the bargaining power of the grower as buyer, plus the composter's ability to utilize the skills of agricultural and horticultural professionals to achieve appropriate and realistic use standards.

The incidence in the past two years of herbicide residues being discovered in composts from commonly used turf chemicals is one example of the changing landscape for compost. While some quickly blamed the agri-chemical companies, the essential problem is the rapid escalation of broad-based recycling in the absence of defined agricultural goals — even, we might add — without a sense of any market.

Working with the agricultural goals of composting, we discovered a lack of qualified assessment regarding what levels of residue were actually harmful, if any. As it turns out, in the case of vineyards, when we determined the actual potential for phytotoxicity in bioassays, and then considered the realistic application rates of the particular compost product in the vineyards — the potential risk could be readily managed. (Brinton & Evans, 2002; 2003).

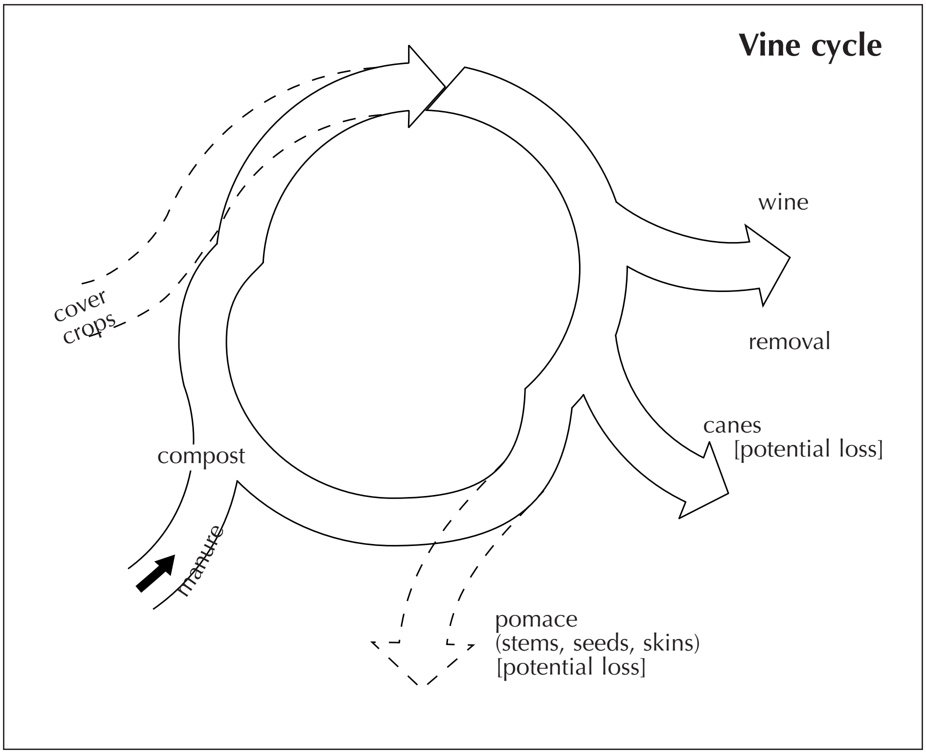
These realities affect both sides of the equation: On one hand, growers desiring to use compost must realize that available products have not necessarily been designed for their particular use, and may meet only minimal environmental standards, set by solid-waste laws designed primarily to protect the consumer and the environment.

On the other hand, a producer who wishes to process waste into compost will find that all the technology and equipment to do it are readily available. The real need is to re-integrate composting into operations where the organic wastes are produced, thereby restoring compost's nature essentially as a product. The problem is that guidelines and standards on how to use it are in their infancy. This ongoing tension between sheer production and proper use enormously intensifies the need for quality management at all levels.

The returned nutrients and organic matter have their own value and belong essentially to the vineyard cycle, as we will show. This means that the value of the nutrient and organic matter in the compost directly offsets expenses that would otherwise be incurred. (For example, we have found most composts have $12 to $15/ton of nutrient value alone, and in organic-BTU value, a form of currency that relates to microbial ecology, there is another $15/ton potential.) (Parnes, 1990).

In addition, if you do your own composting, tip fees are not a controlling issue anymore since the potential cost savings of composting over hauling waste to a dumpsite or special landfill are obvious.

Finally, governmental rules and regulations fall to the side except in the case of very large vineyard operations. For example, in California, to create a vineyard compost site that will be less than 2,500 cu.yds/year, only a grading permit is required. These minimal size limits vary by state and by the type of input waste



that is being used. What simply remains is to set up composting properly, to fully understand the nature of the materials and the minimal equipment required, and to possess an adequate concept of the biology and chemistry of the process in order to produce a useful product.

Quantities of pomace and other wastes

Grape pomace, the result of pressing grapes for wine and juice, is an unusual product for which practitioners and scientists have struggled to find an effective recycling and disposal method. The Italians long ago created grappa from fermented pomace. The French distill it for *marc brandy*. Creating grappa or brandy reduces the vineyard waste stream still further — by about another 25% to 30% — so that the final quantities disposed of have traditionally been more easily managed in a sustainable fashion within small acreages.

Pomace is rich in nutrients, such as potassium, calcium and nitrogen. European experience indicates that pomace, when recycled, contributes back to the soil about ⅓ to ½ of the nutrient and organic matter that the grape removes in its yields.

Below, we will look at some actual calculations and laboratory values we have determined for these nutrient, organic matter, and energy traits of vineyard wastes. Careful supplementation of pomace, prior to composting, to condition it, ends up largely filling the other two-thirds to one-half portion of needed organic matter and nutrients, thereby closing the cycle for the vineyard. Naturally, soil tillage and cover cropping — especially the use of legumes and other cover crops in the vineyard, plus the losses that occur in leaching and erosion — will significantly influence the degree to which, a relatively balanced nutrient and soil organic matter budget can be attained by composting. The beauty with grapes is that so much of this concept, once practiced, can be seen and tasted.

Grape pomace, however, is a very unusual waste. Owing to its unique composition, especially the high content of lignified tissue in the seeds and stems, plus the acidic and partially fermented nature of pomace, it decomposes very slowly. Seeds are often visible months to years after stockpiling — and even after composting.

Table I. Laboratory composition of pomace by-product

SAMPLE	Water	pH	C:N Ratio	Density g/cc	Salt, mmhos	Organic Matter	Total-N	Potash
POMACE						%dm	%dm	%dm
(merlot mix)	14.7%	6.4	19.5	0.36	1.9	91.6%	2.53%	1.8%
Pomace (Range of Values)	12–85%	3.5–6.5	18–27	0.3–0.5	1.0–2.5	90–94%	1.8–2.6%	1.5–3.0%
Per ton of wet waste (avg)	1000 lbs	–	–	25 lbs/ft^3	–	910 lbs	25 lbs	20 lbs

In a recent compost project at McNab Ranch (Ukiah, CA), we identified partially decayed grape seeds by optical microscopy, one year after composting was started (see photo images). In fact, having started with about 5% seeds in the initial compost mix, the end compost had more than 12%, resulting from concentration as the rest of the organic matter decayed. However, these remaining seeds are certainly not viable and are, in fact, partly humified. In contrast, if you spread pomace raw, you can count on seeds sprouting within the vineyard.

There's another potential limitation with pomace. The low alcohol content of the pomace residue relegates it by some state laws, such as in California, to a special landfill category.

Our view is that maintaining a healthy balance in a vineyard is more attainable by appropriate recycling via composting of pomace and other grape residues. The value and significance of this recycling must be calculated as closely as possible, since the obvious nutrients and organic content will have an effect, and quality grapes are sensitive to over-fertilization. Conducted properly, the nutrient and humus needs of the vineyard, in concert with tillage and cover cropping patterns, can be sustainably managed with a minimum of additional external soil inputs.

Test traits of pomace: balancing for composting

Pomace — resulting from pressing grapes — is essentially a heterogeneous mixture of seeds, skins, and pulp, and usually also the stalks, depending on when de-stemming occurs. In any event, the ratio of the four elements varies with grape variety and yield levels. Using University of California-Davis and Penaud's ranges, we calculate that pomace, after pressing, has an average of 8% seeds, 10% stalks/stems, 25% skins, and 57% pulp.

If de-stemming is done prior to crushing, then a separate pile of stalks results, which can be mixed back in to create compost source material. In Europe, before changes in environmental rules in 1995, many vineyards burned the stalks (*rafle* in French). Currently, many are composted. In the Languedoc-Roussillon region, we recently learned of 40 cellars representing 2,000 growers pooling pomace after distilling marc brandy. The result is 20,000 tons of compost, which is delivered back to willing growers — and the demand exceeds the supply!

Pomace, as a whole is relatively rich in nitrogen, potassium, and calcium. Nitrogen is largely in the seeds and potassium in the stalks, juice, and pulp. Most estimates rank potassium as the most prevalent nutrient in pomace, followed closely by calcium and nitrogen; the ratios of the three vary with variety and yield (Gärtel, 1984; Winkler). These represent the very nutrients we want to recapture for the vineyard. The organic matter content is also obviously very high — this represents potential soil humus to compensate for natural soil losses. If pomace were dried, the analysis in terms of N-P-K-Ca would be nearly 2-0.5-2-2; a respectable composition.

It is instructive to examine a pomace analysis in view of composting (see Table I). We show a specific test of a general pomace mixture from a winery,

Table II. Laboratory composition of finished pomace/manure compost

SAMPLE	Water	pH	C:N Ratio	Density g/cc	Salt, mmhos	Organic Matter	Total-N	K	Ca
Finished pomace/ manure compost	40.0%	8.3	11.0	0.8	12.0%	42.0%	2.20%	2.6%	2.4%

compared to a range of values we have observed in the laboratory. This stockpiled material possessed somewhat unusual pH of close to neutral. The ranges show what can be expected, however, indicating that testing of pH prior to composting is helpful.

From a compost textbook viewpoint, the C:N ratio of pomace appears ideal for composting. But textbook guidelines can be very misleading, and we rarely use them. Even with its relatively low C:N ratio, pomace should be thought of more as a "carbonaceous" waste. This is because of its high percentage of lignified structure, ranging from 17% to 35% of the total dry weight. The nitrogen, in the form of lignified protein inside the seeds, is highly unavailable. Thus, the customary blending with "carbonaceous matter" would not be in the best interests of composting. Even worse, the porosity of the stems component may be so high as to cause excessive drainage and drying.

Another important point is that pomace typically possesses a very low pH — depending on the variety, but usually in the range 3.5 to 3.8. Stockpiling pomace in open piles exposed to air causes a natural drift upwards, but this is hard to predict, since it depends on so many factors: moisture content, size of pile, and amount of air. There can even be post-stockpiling fermentation under wetter conditions with a shift into acetic acid production, making the pomace more difficult to compost. This mostly low pH of pomace is partly why stockpiling pomace rarely results in *compost*. Compost microbes require at least a pH of 6.2 to really get started.

If you do not compost, consider these raw traits and how undesirable they may be for direct raw land application! To go further, and make a product, some simple guidelines are needed. It is essential to blend in other materials that possess complementary properties. We call this "conditioning." One rule of thumb is that the added ingredients or conditioners must be rich in available carbon and low in lignin, and they must possess a proper initial C:N ratio (in the range of 17 to 30).

The C:N ratio is discussed a lot in compost literature, yet, since the C:N of pomace is quite often satisfactory, you don't want to be adding any other ingredients that need their own C:N adjusted! (That's one reason we don't recommend wood chips unless you are trying to recycle old barrels.) We prefer manures that contain ample bedding — enough course material to act as a major (but temporary) structural support for the compost. These also supply pH-modifying factors (such as raising the pH to at least 6.5). Dairy, cattle, and horse manures that have been blended with straw or hay are preferred.

There are some options that do not include substantial quantities of cattle manure (if unavailable). One approach would be to shred the stems to improve particle contact, since normally the pomace cannot be kept moist from excessive porosity. Shredded landscape-greenwaste could then be added at any ratio so long as the CN of the whole mix remains below 30. We discourage use in vineyards of carbonaceous composts which turn into a sink rather than a source for nutrients. There is a danger that use of greenwaste alone will not correct the low initial pH of some pomaces, so this must be checked prior and after mixing.

Considering a nutrient budget, there's an astonishing discovery that comes after balancing the pomace in this way prior to composting. Assuming we are using approximately a 50/50 volume mix ratio (pomace: manure), the nutrient concentrations by analysis are about the same as what we started with, but the mass is *now twice* as large, due to the added manure. Thus, the earlier rule of thumb (about one-third to half of the vineyard needs being provided for by pomace recycling), is now brought up to a range of two-thirds to nearly 100%. That's nutrient-sensible compost recycling.

What remains is to adjust the quality of vine growth with management practices: cover cropping (with its own nutrient needs), tillage that partly regulates the supply of nitrogen, and pruning, which controls overall vigor. This is only to say that nutrients and organic matter contained in finished pomace-compost are just the start of a well-managed soil-nutrient budget for a vineyard, a budget that is frustratingly hard to calculate, since it is not an exact science. The objective is *simple sustainability* based on sound and conservative use of resources, backed by careful observations on quality of growth and measurements of inputs relative to outputs to validate the performance.

A simple scheme for the input side of a nutrient budget that includes compost would be as follows (more in Part II):

Compost input (t/a) x nutrient content x availability factors (such as for N-P-K-Ca) = nutrient input + other inputs (compost from previous year x availability factor one-half of previous year) + (estimated legume input of nitrogen) + (natural release of soil nutrients) = estimate of total nutrients available.

Composting will not make the nutrient budget in a vineyard any simpler; in fact it adds factors (such as nitrogen availability) that are less easily measured and calculated. Nevertheless, the uncertainties are mostly in your favor.

If using cover crops, consider vine density; up to two-thirds of a vineyard may be non-grape crops with their own nutrient needs. There are also losses such as from canes and debris that may not be recycled, plus normal weathering and leaching that are difficult to quantify.

What amount of compost works in the end? As little as 1 ton per acre (TPA) up to 4 or 5 TPA (broadcast application) may compensate for these various needs. If more than that, there should be special nutrient needs or the sheer amount of nutrients may drive uncontrollable vigor.

How to do it

With all the considerations of C:N, nutrients, and texture for pomace-composting, the real work remains to be done: putting the piles together and physically managing them. Whereas errors and alterations in the flow of materials lead to qualitative problems, miscalculations in the area of compost operations may be very costly — and result in environmental damage. Examples include: odors from overly large piles, leaching in spring rains from poorly controlled sites, insect problems related to stockpiled pomace and manure prior to mixing (such as fruit flies and household flies).

The following is a list of essential prerequisites, starting with the highest priority:

1) Site layout — Must be adequate to handle the volume of flow and to withstand equipment traffic under the most wet conditions expected.

2) Equipment — Proper selection of loaders and field spreaders to handle input and spreading of materials.

Turning equipment must also be considered for what cannot already be managed with #2 above. The authors consider special turners to be strictly optional.

3) Monitoring tool — Long-stem temperature probe. Oxygen and CO_2 sensors are rarely essential to making a good product, but they do provide information very interesting to compost practioners.

One cannot over-emphasize the need for proper site design, and usually the most basic state regulations for compost sites recognize this. Many well-intentioned efforts at composting are compromised as a result of choosing a poor location and a poor soil type on which to pile the materials.

It is preferable to have an elevated, well-drained location, but paving may not be necessary. One can use a compacted surface similar to a gravel parking lot, or a road surface in the vineyard that possesses adequate side access.

The objective is to be able to pile and move materials late in the year, and then again intensively in the spring, prior to final turning and use in a vineyard. A popular method in Switzerland and central France is called "field-edge composting," with compost windrows laid out along vineyard and farm-gravel roads, assuring at least one side has a solid surface for year-round access.

Growers often ask: "Given a good site, what is the ideal means of composting?" In a recent composting study we participated in with Cornell Waste Management Institute in New York state, composters all over the state had their products tested, and results related to composting methods.

No distinct advantage emerged for any specific method, whether passive-aerated windrows (PAWS) or intensive windrowing. PAWS composting originated in Canada, and refers to piles being placed over perforated PVC drainage pipe, allowing air entrance passively into the bottom of the pile. Windrows, in contrast, are laid out in long rows and turned with a farm-based power turner, such as a PTO-driven compost turner, or loaded into a manure spreader and thrown back into a windrow.

In the New York study, simple factors like moisture content appeared to exert a significant influence on both nutrient content and the maturing process. Moisture, in turn, appeared to control pH, and composts had higher, less desirable pH values longer if they were maintained too moist. What was too moist? This refers to compost being close to saturation in water content. As with soils being near field capacity, a compost has a certain holding ability dictated largely by how much organic matter is present. This makes it hard to state categorically what is ideal moisture.

In soils, organic matter plays a much less significant role in water holding capacity, where texture is more important. For compost, the organic content dictates optimal levels of moisture, being about 60% at the beginning, and declining steadily to under 35% during the compost process, depending on age of material.

In the Cornell study, the most significant factor in compost was the type of compost-pad design, which brings us back to site layout. Of 25 compost sites we examined, those with a lower quality pad (called "unimproved" in the study) were associated with lower organic content, lower nutrients, and higher weed seed counts. This suggests composts may tend to leach and have excessive soil mixed into them when made on poorly controlled ground.

Another factor was noted in a related study conducted by Woods End Laboratory for the U.S. Department of Agriculture (USDA) technical center in Chester, PA (1995). The study examined how differing intensities of composting influence the quality and pathogen content. The astonishing result: while twice weekly mechanical turning did decrease the amount of time to completion, it also significantly increased nutrient losses, especially nitrogen and organic matter.

The advantage to mechanized turning was found in the homogenization of the piles, which made the material look a lot better and spread more easily, but the increased cost of this action has to be weighed against the value for the end-use. For example, twice-weekly mechanized turning for 16 weeks cost a total of \$41.23/ton, compared to \$6.75/ton for the same manure turned with a bucket loader every two weeks.

We note these facts because it is often assumed that composters, especially organic or biodynamic growers, have specific methods or theories for composting. This is not the case and it certainly isn't necessary. What we mean here is that, first, compost is thought to require high-technology, which it does not, and second, biodynamic growers are thought to be anti-technology, which is not true.

Recent adaptations of composting methods include various forms of

Table III. Desired attributes in initial compost mix:

1) bulk density, wet weight, 1000 to 1200 lbs. per cubic yard
2) pH >6.0
3) CN ratio between 20 to 30.
4) Moisture content not more than 70% of water holding capacity.
5) Temperatures after heat-up in range 130ºF to 140ºF for two weeks, turned once, then temperatures may be in optimal range of 110ºF to 140ºF thereafter.

How to tell if compost is too wet

To get the moisture correct, we use a simple technique which is called a "Faust Probe" in Germany. A fist-full of compost is taken in the hand and squeezed tightly. If moisture but not free water appears between the fingers, the moisture is ideal; if however, water flows out of the tightly clenched fist, it is too wet.

agricultural technology, such as bucket loaders and manure spreaders used for turning, but there is no concise or theoretical basis for these differences in organic and biodynamic circles.

It is true, however, that biodynamic methods tend to be low-tech, favoring the environment of the compost pile over the mechanical aspect of how it is handled. But neither organic nor biodynamic growers are exempt from the basic rules of site layout and proper blending of initial ingredients. A lot of anxiety concerning equipment and quality could be put aside by determined and unbiased focus on the basics of the composting process.

Even more recently, the rapid growth of the green waste composting industry has prompted significant upgrading of available equipment. While in many cases, these developments represent cost-saving improvements, the intrinsic biological process of composting — as our USDA and New York state studies for Woods End have shown — remains essentially unchanged.

If your compost is too wet, no amount of turning is likely to fix it. We consider the same to be true with regard to microbes. You need only establish the proper environment and in most cases the result will be a diverse, active microbial population. We have found that no amount of additional microbes will fix a poor environment, or repair a failed compost.

However, if one is unable to make a ball of compost stick together, the mixture is most likely too dry, which may also be confirmed by conspicuous presence of white mold in the compost giving the piles the appearance of "ashing."

Similarly, with static-aerated compost piles, a form of mechanical-forced aeration that was popularized for sludge by the USDA in Beltsville, MD in the late1970s, if the pile is too dense or too wet, we have observed that blowing of air can result in obvious short-circuiting, where the air takes the path of least resistance out of the pile. This can also be a problem in high-tech compost systems where piles are inside bags or in controlled, aerated tanks. Thus, it all comes back to choosing proper initial mixes and getting the texture and moisture conditioned correctly at the start. Once these conditions are correct, then an appropriate form of technology, minimizing intervention, will be most cost-effective.

Summary

Given the seasonal realities of vineyard management, the rapidity of composting is not a critical factor for success. Sound practices are. A six- to 10-month process is likely to prove the safest and most useful approach. This allows sufficient time for stalks and seeds to break down and lose viability, with a corresponding full stabilization and pathogen-destruction in the composting material. ■

In Part II, the authors will explore specifics of obtaining compost and use of compost in the vineyard for nutrient and disease control purposes.

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