PART II

SUSTAINABLE composting IN THE VINEYARD

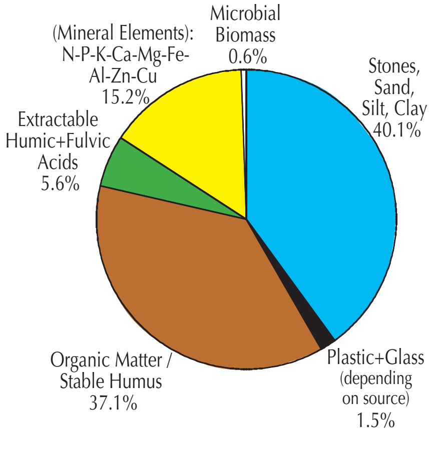
BY Will Brinton & Alan York

In France, what is known today as traditional viticulture evolved after thousands of years of trial and error that created a basic understanding of the nature of the plant and its relationship to a site (soil and climate).

A review of the soil characteristics of the world's most recognized vineyards is very revealing in regard to soil quality. This became the basis by which a system of classification was developed known as AOC (Appellation d'Origine Contrôlée) in France. The AOC system evolved into a national reality in the 1930s as a result of various factors including economic depression, widespread cultivation of hybrids, and uncontrolled wine blending.

Presently, AOC regulations oversee production areas, vine varieties, ripeness and alcoholic strength, yields, viticulture (vine density, pruning, vine training system, and irrigation), and winemaking and distillation.

Figure I: Average composition of finished compost



According to Richard Smart and John Gladstone, "Old World opinions — especially in France — strongly emphasize soil effects. It is a principal basis for the concept of *terroir,* which underlies the official French AOC system. New World opinion has tended to minimize the role of soil and instead to stress major differences in regional climate, or macroclimate."[20]

Terroir may be grasped as "authentic fertility" — the reliance principally on what the deep soil profile within a landscape offers. An additional aspect, which bridges tradition with the modern ecology of recycling, is that this local, site-specific quality is fostered by recycling of the vineyard's own residues and nutrients, supplemented only to the extent needed (see Part I, ***PWV*** Sept/Oct 2003) to make composting successful.

The question is: With an understanding of the nature of the grape and its traditional predilection for deep-soil, low-nutrient conditions, how to best use and apply compost to foster balanced vine growth? Can compost use be overdone? If so, how? Visual indicators of excessive supply of nutrients are often the best references.

It is necessary to first examine what is referred to in modern terms as soil quality. Soil quality is defined as the combined effects of biological, chemical, and physical properties.[1] Compost contributes indirectly and holistically to this aggregate of soil quality in ways that are hard to quantify. These include soil nutrient adsorption, water-holding capacity, and biological disease suppression traits.

Wine grape culture defies, to a large extent, knowledge we have from common agronomic rules for fertilization and attainment of yield and the approach taken to *site*-oriented production. Within the framework of wines for mass consumption, based on high-yielding grape vines, the agronomic model may have greater validity.

A case where a positive trait of compost may be a negative in viticulture is in the behavior of rootlets. Roots love compost and may come to the surface if compost has been layered heavily on the soil. The shock to the grapes comes later, under dry conditions, when these roots cannot survive.

From years of experience, it has been found that heavy applications of compost (more than 10 tons/acre) all too easily encourage surface feeding. It would be better for vines to *seek out* water and deeper layer minerals, which better fits the concept of soil and site-specific management.

Low input, site-specific

A significant body of evidence supporting the concept of local soil quality is seen in long-term fertility studies. In Leigh and Johnston's work (1994), the basis of long-term soil productivity is revealed by examining field research plots that have been run

Table I: Choosing Compost

- Make it yourself, if possible,
- If you have to buy in compost, consider asking the following:
  - What are source ingredients?
  - Has it been tested by a lab familiar with compost?
  - Is a sample available to examine?
- You should also find out:
  - Are grower reports on use of the product available?
  - Is the supply seasonal? How so?

Table II: Nutrient mineral composition of pomace compost[a]

IN COMPOST	Organic Matter	Total-Nitrogen	Potash (K)	Calcium (Ca)	Phosphorus (P)
lbs/ ton as is[b]	460	23	28	27	5
Per 4 tons	1840	92	112	111	20
Per 10 tons	4600	230	280	278	50

(a) Compost prepared at Benziger Family Vineyards, Glen Ellen, CA. (b) Average of three batches.

continuously for 150 years in Rothamsted, England.[2]

One finding is that conservative additions of manure over decades support soil improvements that persist long after the amendments are discontinued. In contrast, long-term grass plots receiving no fertilizer stabilized at sustainable, low yields, with roots colonized to a considerable soil depth. The grasses were apparently drawing on the incalculably large but only slightly available reserves in the deep profile.

The work of Bordeaux researcher Dr. G. Seguin provides an excellent basis for appreciating the complex value of soils.[5] He stresses that the best soils for wine quality have the following characteristics:

- Moderately deep to deep;
- Fairly light-textured, often with gravel through much of the profile and at the surface;
- Free draining;
- Sufficiently high in organic matter to give soil friability, a healthy worm population, and adequate nutrient-holding capacity, but not, as a rule, particularly high in organic matter;
- Relatively infertile overall, supplying enough mineral elements for healthy vine growth, but only enough nitrogen early in the season to promote moderate vegetative vigor.

The combination of all factors — the gradual and very slight natural weathering of soil minerals, deposition of wind and rain-borne nutrients, and microbial symbioses such as mycorhizal relationships which are very common in grapes — aids a plant's ability to extract sufficient nutrients for ongoing yields with surprisingly little inputs. These observations partly explain the success of low-input viticulture.

Low-input sustainable approaches need not be thought of as exclusive to premium wines, as research will attest. Comprehensive farm studies in Austria support a "farm-organism" concept in general agriculture. There, researchers asked what factors contributed most to quality and performance of the farms. They gathered soil and crop data across four geographical regions and correlated these with quality indicators.

The results indicated that the more management moved a soil away from its typical natural state (such as with heavy liming, mineral balancing, and high nutrient inputs), the less satisfactory was the overall quality.[3] This may be partly due to the well-known fact that over-liming significantly reduces trace element availability.

While these studies are not specific to grapes, there is no reason to believe that results in vineyards would be any different. John Reganold, working at Washington State University-Pullman, has recently shown that apple flavor improves with sustainable soil practices.[22] The same author, working in New Zealand, compared paired groups of farms using conventional and biodynamic practices. The latter group, with significantly fewer inputs, had lower yields but scored higher on a soil-quality index scale.[21]

Evidence increasingly suggests a fundamental contrast exists between the attainment of high yield, which requires increased soil manipulation and inputs, and "sustainable yield," represented by lower yields and fewer inputs but higher quality. However, there is no simple, single formula to strike a balance. For vineyards, the low-input approach fits the site-specific scheme closely.

Compost, a balanced approach

As pressure for sustainable practices and recycling increases, the benefits of compost come more into focus. However, there is a danger in treating compost like a silver bullet. Benefits of compost should not be seen as isolated from but rather in addition to the inherent qualities of the site and soils. As noted in Part I, the mandate to "reduce and recycle" does not automatically result in great soil amendments.

Compost should be handled with quality control practices, just as any other agricultural product. The benefits must be viewed in context of reasonable application rates related to appropriate effort and costs involved, along with the expected outcome.

Over-rating the benefits of compost may serve the interests of the organic community as a *New York Times* article, "A Magic Organic Elixir" suggests.[14] When sensational or panacea-like attributes are assigned to an organic input, especially compost, consumers and growers may be misled. Growers may adopt practices that are costly and don't produce the benefits expected. Or the benefits vary greatly by location in ways that are not described. The following may result:

- Applying too much compost with an imbalance of growth resulting.
- Using compost at the wrong time, to no benefit.
- Not checking the ingredients or quality of compost sufficiently, and finding contamination later.
- Overlooking subtle uses that bring important benefits, such as the value of light applications.

The largest uncertainty about compost is whether benefits are purely of a microbial nature. Stating that the purpose of compost is to provide microbes to the soil can be misleading. Recent scientific reports show that microbial populations and ratios in soil are highly stable, and are mostly dependent on geological and physical traits.[17]

Moreover, these reports indicate that microbe populations in soils do not appear to be appreciably influenced by temporal practices such as tillage and application of organic matter.[18] These findings are consistent with some observations from low-input vineyards that have been successful for generations. The discovery that indigenous soil microbes are very stable supports the notion that the native soil has much to offer.

Microbes in compost cannot be ignored, however. An example of the hard-to-quantify benefits from compost is in the area of plant disease suppression, a controversial topic. Working with grape powdery mildew (*Uncinula necator*) in Alsation vineyards, we have shown that a variety of compost applications may significantly reduce the fungal incidence.[9]

When compost is broadcast directly onto the soil surface, it apparently aids in the decay of the litter, and competes with disease-causative fungi harbored there. Laboratory studies have confirmed that compost microbes inhibit fungal conidia germination. Field plot studies in vineyards have confirmed that this reduces ascospore production the following spring, resulting from overwintering of spores on litter and prunings.[8]

Table III: Worksheet for Whole Vineyard Nutrient Budget with Composting

INPUT SIDE	N – K – Ca – OM	OUTPUT SIDE	N – K – Ca – OM
Based on 3 ton yield + manure		Based on 3 ton/acre grape yield	
Pomace + Manure (a)	49, 62, 59, 1000	Wine grape removal	14, 15, 15, –
		Lost only in juice (b)	6, 9, 9, –
Deposition (c)	11, 0, 2,100	Erosion (d)	5, 8, 20, 300
N-fixation(e)	10, 0, 0, 100	Leaching & mineralization(f)	15, 5, 0, 1200
Supplements + Soil tillage (g)	10, 5, 5, 0	Prunings not recycled (h)	6, 7, 14, –
Total Input	**80, 67, 66, 1200**	**Total Removal**	**31, 29, 43, 1500**
Est. available(i)	**38, 57, 56, 1200**		

Notes to Worksheet:
(a) 3 tons yield = 1.1 tons pomace + 1 ton manure (as is)
(b) estimate using 150 gals/juice/ton and nutrient fractioning into wet/solid portions
(c) Estimates for wet & dry precipitation, CA-EPA
(d) 10 ton/acre loss rate, from NRCS Soil Loss tables.
(e) assuming cover crop in $^1/_2$ rows at $^1/_3$ field density
(f) OM mineralization of 2%/yr of 3%OM soil
(g) tilling releases more N, based on experience
(h) UC-Davis estimate of 1,300-1,500lb/a canes
(i) compost availability N=15%, K & Ca = 85%

Unfortunately, these positive elements of compost all depend on the confounding relationship of disease pressure to meteorological events *and* vineyard management *and* compost quality. As a further caution, it is generally true that the more disease pressure there is, the less chance that compost will have a satisfactory controlling influence.

A German summary of vineyard microbial compost shows the best results to be expected for *Uncinula necator*, with variable results from *Plasmopara viticola*, and unsatisfactory control of *Botrytis cinerea.*[16] A recent study reported in Oregon with compost extracts (tea) used for *Botrytis* in vineyards produced inconclusive findings.[25]

Predicting microbial benefits of compost can be frustrating. For example, on a pound-for-pound basis, compost does not necessarily contain more microorganisms than healthy soil does, which is usually in the range of one million to 100 million per gram. Each laboratory technique for determining soil microbial diversity produces its own numerical results, and interpretation schemes vary tremendously.[12]

Can a healthy soil be successfully inoculated with compost microbes?

Microbes and organic matter in compost are food for healthy soil microbes. In the case of an impoverished soil, there could be appreciable benefits, but we do not know how to determine this. Growers need to be guided by experience. We are very suspicious of ideal ratios or quantities of microorganisms in a soil that can be managed. To our knowledge, this has never been proven.

Woods End Lab has attempted to inoculate compost with selected microbes. The result has been that the introduced bacterial species succumb very quickly to pressure from existing populations. Apparently, these introduced microbes are unable to compete with the better-established, indigenous community.[10]

Woods End Research Laboratory, Inc.
20 Old Rome Road, P.O. Box 297
Mount Vernon, ME 04352/USA
207-293-2457 FAX: 207-293-2488 www.woodsend.ofg

Account: X387	Code: sm Project: 101
· Mike Benziger	Date Received : 08/16/2001
· Benziger Family Winery	Date Reported : 08/31/2001
· 1883 London Ranch Road	Lab ID Number : 5061.2
· Glen Ellen CA 95442	Quality Checked : wfb

COMPOSITION ANALYSIS

Sample Identification: Composted Manure + Pomace 2000; Highway-12

VARIABLE MEASURED	Unit	dry basis	as is basis	Notations †
DENSITY	$lbs \cdot ft^3$	-	51	1365 lbs/yd^3
Solids	%	100.0	52.2	1044 lbs/ton
Moisture	%	0.0	47.8	115 gals/ton
est. water holding capacity	%	143	59	141 gals/ton
Inert and Oversize Matter	%	⇝	17.3	346.0 lbs/ton
pH (paste, H_2O)	$-logH^+$	⇝	8.47	High
Free Carbonates (CO_3)	Rating	⇝	3	V High
Organic Matter	%	43.0	22.4	449 lbs/ton
Conductivity (Salt)	$mmhos \cdot cm^{-1}$	⇝	16.3	M-High
Carbon:Nitrogen (C:N) Ratio	w:w	10.4	10.4	M. Low
Solvita CO_2 Rate	(see chart)	⇝	7	Low-Good
Solvita NH_3 Rate	(see chart)	⇝	5	Absent-Good
Maturity Index	(see chart)	⇝	7	Mature
Total Mineral Nutrients				
Total Nitrogen	%	2.240	1.169	lbs/ton: 23.4
Phosphorus (P)	%	0.746	0.390	7.8
Potassium (K)	%	2.768	1.445	28.9
Sodium (Na)	%	0.401	0.209	4.2
Calcium (Ca)	%	2.447	1.277	25.5
Magnesium (Mg)	%	1.051	0.549	11.0

Notes: ppm = mg/kg < = less than MLD (minimum level of detection); nd = none detected
†Notations refer to various additional units of reporting

Woods End is a Compost Analysis Proficiency (CAP) member laboratory

Still, others have reported some successes.

The variable results are not surprising; they match recent reports from European microbial research. The idea of importing microbes from some external source, and thereby significantly improving or altering a soil or compost, seems naive. However, we won't deny there are important discoveries to be made here.

Balancing nutrients and composts

It is important to not lose sight of the nutrients that occupy a significant fraction of compost (see Figure I). Table II shows the composition of finished grape pomace compost, made according to the recipe from Part I (***PWV***, Sept/Oct 2003).

A single ton of pomace compost provides a significant amount of N-P-K-Ca. The majority of the P-K-Ca will be readily available, since there are no factors in compost that hold onto these elements strongly. However, it is uncertain how much nitrogen will be made available — the more aged and mature the compost, generally the less N is available.

The moisture content of the soil where compost is applied also plays a large secondary role in the actual release rate. But if only one-fifth of the nitrogen is made available, then 4 tons of compost provides 20 lbs of available N. In contrast, a 3-ton crop of grapes removes approximately 14 lbs/N.[15] Below are other factors that must be known before concluding this is the right amount of nutrient.

The low rate of N release from compost may be fortuitous, since it is essentially what is desired in a vineyard; otherwise, one could not even apply one ton of compost without potentially stimulating excessive vigor. Trial and error are required to set the application rate to match the vigor.

We have been involved with sites, such as the McNab Ranch (Ukiah, CA), where vigor is such that applying even one ton/acre of pomace compost is unnecessary. Other similar sites are found throughout wine growing regions.

The primary way to reduce soil vigor is to use grass cover crops to absorb nitrogen and water and then reduce or eliminate tillage and irrigation. Theoretically, if there is too much N-release from a compost, it can be managed with these tools.

These facts about compost and nutrient release may seem a curious contradiction to sustainable management and compost recycling. Nevertheless, truly "natural" viticulture will always mean using the soil's best abilities to produce a crop. Compost can be a way to carefully supplement with site-specific nutrients covering short and longer term depletion from grape removal.

Conservative recycling of compost — returning pomace year after year via composting to the site where it came from — thus leads to a uniquely genuine form of nutrient support for grape yields and flavor which is highly site-specific.

Vineyard nutrient budgets

With these points in mind, the new vineyard input formula becomes: soil reserves released by natural weathering + available nutrients in entire soil-profile + microbial augmented release of nutrients + added nutrients from recycled compost + other supplements, N-fixation inputs, wind deposits, rain deposited nutrients + reduced disease pressure = total input factors for plant development. Most of these can be quantified.

Table III shows a nutrient budget with the input and outputs for the major nutrients plus organic matter compared side by side.

In preparing a nutrient budget, many assumptions must be made and then adjusted for a particular vineyard and location. There is no ideal budget or single scheme. It is somewhat analogous to preparing a business plan, and then substituting actuals for projections as information becomes available.

In Table III, actual analyses of pomace compost are used. The model assumes a 3-ton/acre grape yield. Clearly, the only substantial nutrient removal is in the pressed juice. However, not all nutrients in juice are actually removed, as some return in the pomace, and therefore go back into the input side of the equation.

It is assumed that all pomace after pressing is composted using the formula of a 50% addition of manure to balance the pomace, which results in an increase of the nutrient input. Thus, from a wet yield of 6,000 lbs/acre of grapes, one ton of wet pomace results after pressing, which is combined with approximately one ton of mixed manure. The model assumes this amount is then reapplied to each acre, although this may not necessarily apply in every situation.

In addition to assuming a certain yield and recovery, several estimates of probable losses plus other gains are predicted. Environmental gains and losses in a growing system are clearly variable and sometimes very high.[24] Many remain largely unknown in the absence of a good way to measure them.

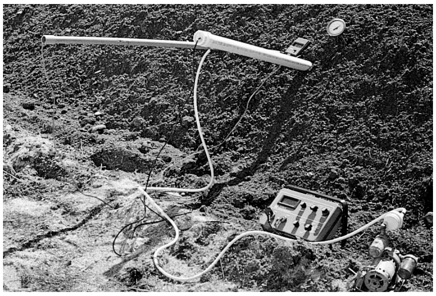
This is where, in the end, careful visual observation of vigor and quality are important — the model gets adjusted accordingly, up or down. Up if the predictions are too pessimistic, and down if too optimistic. With experience, it is easy to determine if a budget model is relevant or not.

Note: Even where there are numbers, a nutrient budget is never an exact science. But neither is soil testing. Soil chemical tests give nutrient values by a particular extraction for a thin topsoil layer, even though roots may be exploiting much deeper layers.

Tissue testing is often done, and is thought of as sharpening estimates made from a soil test. However, tissue concentrations must be interpreted by comparing them to tables for the appropriate variety and region, if available. In this way, all models have validity but also limitations.

We are cautious about the value of soil and tissue tests in established vineyards. These are tools that are very valuable for start-up years and where deficiencies are observed.

Using the whole-system budget approach, some surprising conclusions result. In the example provided, the end-effect of composting pomace from a 3-ton grape yield is that there are enough inputs to offset the calculated nutrient removal and estimated losses for N-K-Ca for all sources. Net loss of organic matter by natural mineralization is also closely covered. Soil cover crops contribute organic matter and were not added in this model.



Monitoring active compost for temperature (long-stemmed probe) and oxygen (digital membrane meter). If the temperature is very high and/or oxygen is very low (under 2%), the pile may be turned.

Note that the total-nitrogen input in the model using compost appears high compared to its removal. However, only a fraction of the total N from natural sources is plant-available in any season. We assumed 15% availability in the first year after compost application.

A UC Davis study comparing the nitrogen benefits in vineyards from various cover crops and compost ranked compost on the low end.[13] Therefore, on light soils where N-supply is very critical, it is important to know more precisely the potential N-release for a compost. There are lab tests to measure N-mineralization from compost. Since site and climate have so much to do with performance, trial and error in the vineyard will be essential, however.

Conclusion

The satisfying finding here is that the system represented in this model does not appear to be too far off. Remove one or another factor, especially the recycled pomace, and it changes enormously. Increase the production demand and eliminate nutrient recycling from the pomace, and this worksheet quickly turns into red ink!

If one is not recycling one's own pomace via compost, then purchases of compost should be tied to a grape production model, otherwise the inputs may be too high or too low. This is why we recommend assessing the production objectives before applying a model. True, it is an exploratory process, requiring some experimentation.

The important caveat, to adapt an old saying, is: An ounce of visual observation of the grapes may be worth a pound of input of compost.■

William F. Brinton, Ph.D. studied agronomy and environmental science and is founder and director of Woods End Research Laboratory, Mt. Vernon, Maine with a branch office in Europe.

Alan York, past president of the Biodynamic Agricultural Association, is a trained horticulturist and is an international consultant for wine grape growers.

References

1. Doran, J.W., D.F. Bezdicek, D.C. Coleman, and B.A. Stewart (1994). "Defining Soil Quality for a Sustainable Environment." *Soil Sci. Soc. Amer*. Spec. Publ.# 35 , Madison, WI.

2. Leigh, R.A., A.E. Johnson (1994). *Long-term Experiments in Agricultural and Ecological Sciences*. CAB International, London.

3. Schiller, H., J. Gusenleiter, E. Lengauer, B. Hofer (1967). *Fruchbarkeitstörungen bei Rindern in Zusammenhang mit Düngung, Flora und Mineralstoffgehalt des Wiesenfutters*. Linz Agricultural Experiment Station, Linz Austria.

4. Robinson, J. Ed. (1999). *The Oxford Companion to Wine* 2nd Edition. Oxford Univ. Press.

5. Seguin, G. (1986) "*Terroirs*– A pedology of wine growing." *Experientia*, 42: 861-872.

6. Larney, F.J., L.J. Yanke, J.M. Miller, T.A. McAllister (2003). "Fate of Coliform Bacteria in Composted Beef Cattle Feedlot Manure." *J. Environ. Qual*. 32:1508-1515.

7. Brinton, W. (2003). "Complexity and Charade in the World of Soil Microbes: A Plea for Balance." *Journal Biodynamics* Vol. 2.

8. Brinton, W., and A. Traenkner (1996). "Investigations into Liquid Compost Extracts." *Biocycle*. 37:68-71.

9. Brinton, W. (1997). "Compost for Control of Grape Powdery Mildew." *Jrnl Biodynamics* Vol 3.

10. Droffner, M. and W. Brinton (1994). "Microbial Approaches to the Characterization of Composting Process." *Compost Sci. Util*. Vol. 2.

11. Droffner, M. and W. Brinton (1995). "Evidence for the Prominence of Well Characterized Mesophilic Bacteria in Thermophilic Composting Environments." *Biomass & Bioenergy* 8:191-195 Elsevier Sci Ltd.

12. Dunbar, J. *et al.,* (2002). "Empirical and Theoretical Bacterial Diversity in Four Arizona Soils." *Appl. Env. Microbiol*. 68: 3035-3045.

13. Hirschfelt, D., W. Peacock, P. Christensen (1992). "The Effects of Cover Crops and Compost on Grapevine Nutrition and Growth." Univ. California-Davis SAREP.

14. Homeyer, H. (2003). "A Magical Organic Elixir Goes High-Tech." *New York Times*. Jan. 5, 2003.

15. LIVE (2000). "Soil and Fertilizers." In *Low Input Viticulture and Enology*. Oregon State Univ. http://berrygrape.oregon state.edu/LIVE/.

16. Fischer, B. (1996). *Beiträge-zur Entwicklung Umweltschonender Pfanzenschutzsysteme im Weinbau.* "Contributions to Environmental Pest Control in Vineyards," Univ. Bonn Dissertation

17. Girvan, M., *et al.* (2003). "Soil Type Is the primary Determinant of the Composition of the Total and Active Bacterial Communities in Arable Soils." *Appl. Env. Microbiol*. 69:1800-1809.

18. Sessitsch, A., *et al.* (2001). "Microbial Population Structures in Soil Particle Size Fractions of a Long Term Fertilizer Field Experiment." *Appl. Env. Microbiol*. 67: 4215-4224.

19. Odell, R.T., W.M. Walker, L.V. Boone, and M.G. Oldham (1983). "The Morrow Plots: A Century of Learning." Illinois Agric. Exp. Stn. Bull. 775.

20. Smart, R.E. and J. Gladstones (1999). "Soil and Wine Quality." In *The Oxford Companion to Wine*. 2nd Edition. J. Robinson (Ed) Oxford Univ. Press.

21. Reganold, J.P., A.S. Palmer, J.C. Lockhart, and A.N. Macgregor (1993). "Soil Quality and Financial Performance of Biodynamic and Conventional farms in New Zealand." *Science*. 260: 344-349.

22. Reganold, J.P., J.D. Glover, P.K. Andrews, and H.R. Hinman (2001). "Sustainability of Three Apple Production Systems." *Nature*. 410: 926-930.

23. Blanchard, C.H., M. and S. Tanenbaum, (1996). *Regional Estimates of Acid Deposition Fluxes in California.* Air Resources Board, CA-EPA. No. 96-13.

24. Soule, J.J., J. Piper (1992). *Farming in Nature's Image; An Ecological Approach to Agriculture.* Island Press.

25. SARE (2003). "Control of Botrytis by Compost Tea Applications on Grapes in Oregon." Western Region SARE Project SW00-039. http://wsare/usu.edu.

Reprinted from:

PRACTICAL WINERY & VINEYARD

58 Paul Drive, Ste. D, San Rafael, CA 94903 • 415-479-5819

Visit our website:
www.practicalwinery.com
to learn more about ***PWV.***