FINGER LAKES
VINEYARD NOTES

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RECOGNIZING AND RESPONDING TO DROUGHT STRESS IN VINEYARDS

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Even the federal government recognizes that central New York is having a drought. Table 1 indicates that rainfall during the first three months of the growing season at Geneva was the second lowest in 100 years.

In addition rainfall from January until May was also 40% below normal. These numbers argue for grower concern, but the scary part is that Geneva's 1999 rainfall is considered above average for the region. Weather instruments show consistently higher rainfall in Geneva than in Branchport or points south.

The Lake Erie region had reasonably adequate rainfall in the early summer, but has received little rain since. Drought symptoms are also being seen in vineyards in the eastern part of the state. Most summer rains have been from thundershowers, not general rainfall. This means that precipitation has been very uneven and the records from any one station poorly represent the region as a whole. There are water stressed vineyards in every part of the state.

The dry status of vineyards prompts us to review what water stress does to vineyards and outline possible grower responses.

Table 1. Precipitation during the period May-July. The ten driest and five wettest years in 100 years of Geneva weather records.

Rank	Year	Inches Rain
100	1936	3.7
99	**1999**	**3.9**
98	1955	3.9
97	1965	4.6
96	1934	4.8
95	1911	4.8
94	1991	5.7
93	1979	6.1
92	1933	6.2
91	1921	6.2
100 year average		9.8
5	1986	14.8
4	1992	15.5
3	1913	16.0
2	1972	18.2
1	1924	24.1

Components of Supply and Demand in the Vineyard. Stress is related to the balance of supply to demand for water. The lowest risk of loss due to drought occurs when the water supply is high and the demand is low. Conversely, when the supply is low and the demand is high, the risk is high and the potential benefits of irrigation are greatest. Besides seasonal rainfall several factors are involved in the total risk, and they should be evaluated separately since some cannot be easily changed while others can. These factors are listed in Table 2.

Table 2. Major factors of water supply and demand in vineyards.

Water Supply Factors		
Soil Water Holding Capacity and Depth	-	Heavier soils hold more water than lighter sands. A volume of sandy soil will hold only 30-40% as much water as a clay soil.
Rooting Depth of Vines	-	Rooting depth not soil depth determines how large a reservoir of water is available for vine function.
Competing Plants in the Vineyard	-	Many weeds or cover crops have denser root systems and successfully compete with vines for limited soil water.
Rainfall, Runoff and Evaporation	-	Water added to the soil surface that runs off is not available to the vine. Evaporation rate determines how fast stored water is used.
Water Demand Factors		
Weather	-	Hot dry weather increases the rate of evaporation
Age of Vines and Leaf Area	-	Young vines have only shallow roots. Vines with large canopies use more water than small ones.
Training System	-	Training systems which have a larger canopy surface like GDC use more water than simple ones.
Crop Levels	-	Large crop loads require full canopy function to mature; they have no "spare" leaves.

Symptoms of water stress. With increasing severity and duration of water stress, vines will develop the following symptoms:

1. The angle between the leaf blade and the petiole will decrease from about 90° to less than 45°.
2. New leaf formation will slow, and most leaves near the shoot apex will be fully expanded.
3. Leaves in direct sunlight will feel "hot" to the touch.
4. Lateral shoots will not become persistent. They will fall at the node attachment.
5. Tendrils will dry up and fall off.
6. The shoot tip will fall and there will be no new leaf production.
7. Shoots will be shorter than normal.
8. Leaves, especially those in full sun, will become pale with a bleached green appearance.
9. Grape berries will be smaller than normal and clusters will tend to be loose.
10. Leaf margins will become scorched.
11. Basal leaves will become chlorotic and fall.
12. Rachis at the ends of clusters will dry out.
13. Depending upon time and intensity of stress, veraíson may be delayed.
14. Fruit may cease soluble solids accumulation. Percent soluble solids (juice brix) may continue to increase because of berry dehydration, but sugar accumulation (soluble solids per berry) will cease.
15. Shoot diameter will be less than normal.
16. Periderm formation will start early.
17. Periderm formation will be incomplete.
18. Berries will shrivel, and for some varieties fall to the ground.

Other consequences of drought:

1. Development of potassium deficiency symptoms in leaves even though the top soil has adequate potassium.
2. Development of other nutrient deficiency symptoms, especially nitrogen.
3. Reduced root system growth.
4. Reduced uptake of sufficient nutrients in late fall and early summer to sustain normal development of flowers the next spring.
5. Grape musts may be either very high or abnormally low in acidity.
6. Musts may not supply wine yeast with the normal compliment of nutrients leading them to break down proteins, metabolize amino acids and produce off flavors.
7. Wines may not age properly.
8. Vine size and capacity to produce a full crop will be reduced for one or several years.
9. Herbicides may not be effective and deep rooted perennials may become established.
10. Insect and other arthropods will tend to reach higher populations than normal.

How much water do vines need in the northeast? Our recent studies indicate that at full canopy in July and August single curtain Concord grapevines in Western NY use about 30-40 gallons of water per vine per week (water use is proportional to leaf area - young vines use less). That works out to just about 3 acre-inches of water per month (see Box below). Notably, 3 inches/ month is very near the monthly average rainfall during the growing season in Western New York.

Estimates of Water Use in Concord Vineyards in New York

Concord vines (8 x 9 foot spacing, healthy mature full canopy) in July average about:
4.3 gal/day = 30 gal/vine/week = 2600 gal/acre /day
0.10 acre-inches /day (about 50% of measured pan evaporation)

(GDC Vines probably use about 10-20% more water due to higher sunlight capture so add about 0.5 acre-inches/month)

Entire Vineyard:
Vines + no cover (soil evaporation) = about 0.10 + 0.02 ac-in = 0.12 ac-in/day
= 3 in/month for vines, 0.5 in/month for bare soil = about 3.5 acre-inches/month

Vines + green cover in row middles = 0.10 + 0.08 ac-in = 0.18 ac-in/day
= 3 in/month for vines + 2.5 in/month for cover crop = 5.5 acre-inches/month

This amount of water is only enough to take care of the vine's needs. Not all rainfall gets to the root zones — there are losses from soil and canopy evaporation and runoff. Weeds and cover crops use a significant amount of water. Water loss through evaporation from bare soil is about 10-20% of vine water use. Green, active cover crops in row middles use about 80% of the water that vines do (see table). So a single curtain Concord vineyard with grass middles uses about 3 acre-inches/month for the vines and 2.5 acre-inches for the covers. If there is only 3 inches of rainfall, the soil water reservoir needs to make up the difference or the vines will suffer some drought stress. In most years, traditional single curtains with conventional pruning normal crop levels and bloom-time herbicides are well balanced to the available rainfall and soil water supply in Western NY.

Will water stress be equally damaging on all vineyards? The response to water stress will be the same for every vineyard. However the impact of that stress may vary depending upon the crop load and the specific use for the grapes produced.

Table grapes are probably most sensitive, because of reduced berry size. Grapes produced for the moderate value market (juice grapes, most Native American varieties and some hybrids) tend to be vulnerable because of the need to maximize yield. High yields are obtained with high crop load. Anything that reduces the “effective” leaf area of maximally cropped vines will reduce current and future yield.

Some markets are not concerned about low sugar, but low sugar means even lower yield. The same buyers who are not concerned with soluble solids may be very concerned about reduced acidity. Most juice grape buyers have a specific soluble solids window for the grapes they harvest. There will be a penalty for not achieving the minimum maturity level.

People tend to think that stressed vines produce premium wine grapes. That is only partially true. As long as post-veraíson leaf and root function are not reduced, the smaller berries of dry years will have a higher proportion of color and aroma compounds found in the skins. However, unless price per ton is

increased, this quality will come at the price of overall reduced value per acre.

When there is more than moderate stress, leaves cease to export photosynthates, berries shrivel, and ripening is affected. In addition to the mineral nutrient fermentation disorders mentioned above, water stressed, shriveled grapes give false maturity readings. Fruit at a typical soluble solids will be less mature than normal. Stressed fruit may never fully ripen and wines produced from them will have fewer ripe fruit aromas and tannins and an imbalance of acid components.

Fruit ripening patterns of stressed vineyards. Moderate stress will just reduce the overall rate of photosynthesis. Fruit will develop normally, but less resources will be available for shoot and root maturation. With increased stress there will be a major depletion of mineral nutrients. Photosynthesis may be essentially stopped, and fruit will develop at the expense of reserves already laid down to sustain next year vine and fruit development. Fruit may reach high soluble solids because of small berry size and berry shriveling, but total carbohydrates may be low. Malic acid may be essentially depleted, but tartaric acid is usually be retained. Fruit may not develop "ripe" tannins or normal aromas. Stressed fruit may encourage off flavors in the wine. Total vine growth, root growth and reserves are reduced. Mineral nutrients needed for spring flower development may not be accumulated. Total number of ripe nodes will be reduced. Canes may not develop normal cold hardiness. Fruit may fail to mature or may fall to the ground. Leaves may show severe nutrient deficiency, especially potassium and nitrogen.

After Harvest. The post harvest period is a time the vine can make up deficiencies caused by excessive crops. If the leaves are not functioning there will be no make up period.

If the soil profile has not become well watered before the ground freezes there may be another problem. When soil moisture freezes it releases heat, and damp soil conducts heat from depth to the surface more efficiently than does dry soil which is full of air spaces. Should there be a period of intense cold at a time when the soil surface is not snow covered, root freezing injury is much more likely when the soil is dry than when is moist.

Table 3. Summary of drought stress impact on vines

Year 1	Year 2
- Reduced vine size - Reduced berry and crop size - Reduced fruit and wine quality - Reduced starch and mineral nutrient reserves accumulation - Reduced winter cold tolerance of trunks, canes and buds - Increased likelihood of cold injury to roots.	- A smaller root system leading to a reduced supply of water, mineral nutrients and root produced growth regulators. - Reduced canopy development - Impaired flower development - Reduced crop capacity, but normal to above normal crop potential per retained node - Shot berry formation, reduction or failure to set fruit

What can I do? For most growers the alternatives are few, and some are quite drastic. They include making up for rainfall deficit by adding water; conserving the present soil moisture, reducing the amount of water used by vines and reducing the impact of the induced overcrop.

Adding water. We assume you have already done what you think is feasible this year. This spring many growers had water trucked in to help newly planted vines get through the season. Others installed trickle irrigation systems. Note in table 1 that three of the driest years on record came in the mid-1930's. There are cycles of wet and dry weather. The combination of a dry cycle at a time when grape prices are relatively favorable might be motivation for you to consider installing an irrigation system.

Those considering installing an irrigation system can use this dry period to advantage. Not every portion of a vineyard will have the same need for supplemental water. A good time to judge relative needs for your different vineyard blocks is when the some vines are showing stress symptoms.

Conserving water. Water conservation approaches include:

1. reduce water use by plants other than grapevines;
2. reduce loss of water from the soil surface;
3. reduce water use by the grapevines.

Weed Control. Non-dormant plants other than grapevines use water regardless of whether they are considered to be a cover crop or weeds. Deep rooted weeds may be even more competitive than more shallow rooted weeds, but the strategy should be to keep what water is available for vine growth. Options are close mowing, herbicide application or cultivation. In general, we would prefer that soil surface not be disturbed late in the season. Dead plants help stabilize soil and reduce erosion hazard. However, late season under-the-row herbicide application may be difficult when the grape leaf canopy extends into the spray zone. Cultivation may be the only-in-the row option, if shielded herbicide sprayers are not available.

Mulch. Water use by a vineyard is called evapotranspiration because water is lost from the soil profile through evaporation and by transpiration through plants (grapes and non-grapes). The primary benefit of mulching is that it reduces direct evaporation from the soil surface. Mulching doesn't add water to the soil, but it does help ensure what water is present is available for plant growth.

Reducing water use by the grapevine. I don't think there is any way to reduce grapevine transpiration (water use) without reducing vine capacity. Anti-transpirants are available. In most cases they conserve water by covering or plugging stomata with a film. They generally reduce photosynthesis in direct proportion to the reduction in transpiration.

Leaves control transpiration, and in the process they are cooled. When transpiration is reduced, evaporative cooling of sun exposed leaves is also reduced. When transpiration is greatly reduced, leaves overheat and become bleached or necrotic. Fully exposed leaves are the ones which do both the most transpiring and the most photosynthesizing. Thus leaf removal through hedging or leaf plucking will reduce capacity. It is doubtful that any form of defoliation will prevent the induced overcrop which comes with drought. A combination of leaf area and crop reduction might reduce overall vine water use, but it is pretty late in the season to think about that approach now.

Reducing impact of the induced overcrop. Moisture stressed vines become functionally overcropped because of reduced photosynthesis. A crop load (weight of fruit in relation to amount of vine's total photosynthesis) that would be acceptable in a year of normal rainfall becomes an overcrop when vine photosynthesis is limited because of water stress. Remember there are several tasks the vine needs to accomplish if current and future productivity is to be maintained. The crop needs to mature sufficiently to satisfy the buyer. Root system size and function need to be maintained so that carbohydrate and nitrogen reserves will be acquired to sustain subsequent early season growth. An adequate root system is also needed to supply mineral nutrients, water and root-produced growth regulators during the following spring. Canes and trunks need a supply of carbohydrates to convert to starch reserves.

Crop Reduction. A stressed vine will ripen its fruit at the cost of accomplishing the other events needed to maintain future productivity. Thus one of the few things that a grower can do is to restore the crop vine balance by reducing the crop size. This is an undesirable option, but future crop failure is also not very desirable.

Cluster thinning. For higher value grapes, selective thinning may be a very desirable option. Removing clusters whose development lags will improve final crop uniformity and improve grape and wine quality.

Early Harvest. Just doing an early harvest may be an option. Conversion from a red wine to a sparkling or rose wine market may allow early harvest. Selling for the cold press as opposed to the hot press market may be feasible for others. Certainly, growers who already plan to sell both ripe and grapes for cold press would be wise to consider which blocks will benefit most from the early harvest.

Foliar Fertilization. Stressed vines develop nutrient deficiency symptoms. However, adding fertilizer to dry soil will not help the vines now, and may create problems later. We do not normally recommend foliar nutrient application. We have had no real success adding foliar nitrogen, but a year like this may call for drastic action. I can't advise growers to spray nitrogen, but I certainly wouldn't advise against it. Just remember, nitrogen can burn foliage, be cautious. On the other hand, wine makers would be justified to add the fully allowable rate of nutrient supplements this year. They well know that low nitrogen musts are prone to the development of off odors and stuck fermentations.

There is more experience with foliar sprays of other elements. Don't expect potassium deficiency symptoms to go away after foliar fertilization, but some relief from magnesium deficiency symptoms may be expected.

Preparing for next spring. Past history has shown that vines go into the spring after a drought year with quite fruitful buds, but that the volume of reserves and roots is reduced. In California there is reference to "drought induced" boron deficiency the spring following a dry fall. The symptoms are similar to those we have called millerandage in New York, and resemble deficiency symptoms of boron and zinc. Although the real cause of these problems have not been nailed down, it seems only prudent for a grower whose block was drought stressed in 1999 to:

1. Retain fewer than usual nodes for fruiting in 2000.
2. Ensure that boron and zinc are not limiting. Ground applications this fall will reach the root zone by spring, but remember a smaller reduced system has a lowered ability to take up soil nutrients. While it is best to supply mineral nutrients through the root system, a combination of soil applied and foliar applied nutrients may be best for the 2000 growing season.
3. Be very alert to any early season stress such as insect feeding or water deficiency next spring.
4. Consider adding the normal amount of nitrogen in several stages next spring and summer.

Is there a market for early harvested grapes? Above we mentioned the advantage of early harvest. There are uses for grapes which are not fully mature. These include sparkling wine, white wine from red varieties, and cold pressing. Barry Shaffer, business specialist with the Lake Erie Regional Grape Program, is exploring the extent to which processors are interested in increasing purchase for these markets in a year of general vine stress. Another use for green grapes is *verjuice*. There is no really established market for this sort of fresh grape vinegar in the U.S., but wineries might consider experimenting with it if some of their vines are severely stressed.

PENNCAP-M AND GUTHION USE LIMITED

Timothy Martinson

By now most of you are probably already aware that methyl parathion, active ingredient of Penncap-M, registration for use on grapes has been cancelled starting next year. Growers may continue to use it this season. In addition use of azimphos-methyl (Guthion) has been limited in the following ways:

- Residue tolerances for pome fruit have been lowered
- Re-entry intervals have been lengthened
- A 'cap' on azinphos methyl production has been agreed to with the manufacturer.

While guthion hasn't been cancelled, the practical effect will probably mean limited or no availability for use on grapes starting in 2000.

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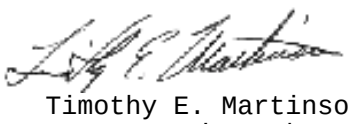

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