Lack of irrigation in 2002 reduced Riesling crop in 2003

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Irrigation has not been traditionally used in Finger Lakes vineyards. But increasingly frequent dry periods during late July and early August are leading us to re-examine the role that water stress before and during veraison plays in influencing quality and yield.

ATA project. Over the past three growing seasons, we have conducted a project to look at how irrigation and nitrogen fertilization influence vine physiology, fruit quality, and wine sensory characteristics in a Riesling vineyard. A major goal was to relate water and nitrogen status of the vines to the appearance of 'atypical aging' (ATA) flavors in wines. Wines with ATA have less varietal character, and off flavors described as 'furniture varnish', 'floor polish', 'waxy', and 'damp dishrag'. The ATA malady is associated with dry production years, and is thought to have something to do with the lack of nitrogen uptake, due to water stress and drought. This experiment tested that idea through direct comparison of wines made from irrigated or non-irrigated vineyards, with or without the application of supplemental foliar or soil-applied nitrogen. The management idea was that growers could reduce or delay the appearance of the ATA symptoms through irrigation or by foliar applications of urea in the weeks before and after veraison.

Today, I'm going to focus strictly on how irrigation affected yield and maturity over the three years of the experiment. We were fortunate (for experimental purposes) to have two very dry years, followed by a wet year in which we applied no irrigation – and essentially treated the 'irrigated' and 'non-irrigated' vineyards the same way. This offered the opportunity to document the 'carryover' effect of the very dry 2002 growing season. The bottom line is that **following two years of drought, the 2003 crop was reduced by up to 50% in the unirrigated blocks compared to the irrigated plots.** This occurred because the severe drought of 2002 brought on water stress that reduced photosynthesis from mid-July through mid-September. As a consequence, ripening was delayed, and pruning weight was reduced by about half compared to irrigated vines that had leaf function throughout the drought.

Drought stress and photosynthesis. Vines depend on water supply to maintain leaf temperature in an optimum range. They do this through evapotranspiration – i.e. cooling by evaporation of water from the leaf surface. When water supply is inadequate, the **stomates,** minute pores through which gas exchange occurs, close, and vine respiration shuts down. This reduces the rate of photosynthesis, because vines can't take in CO_2 from the atmosphere, or respire. So water stress can shut down photosynthesis and raise leaf temperature during the day, resulting in tissue damage. When this occurs in July and August (around veraison), both growth and berry development (including sugar accumulation) suffer. Our data from 2001-2003 illustrate this well:

1. Weather in 2001-2003. Rainfall was significantly below average in 2001 and 2002, and irrigation was applied weekly to the irrigated plots from late July through early September. In 2003, Rainfall was at least average in all months of the growing season, and was two inches above average in May and August.

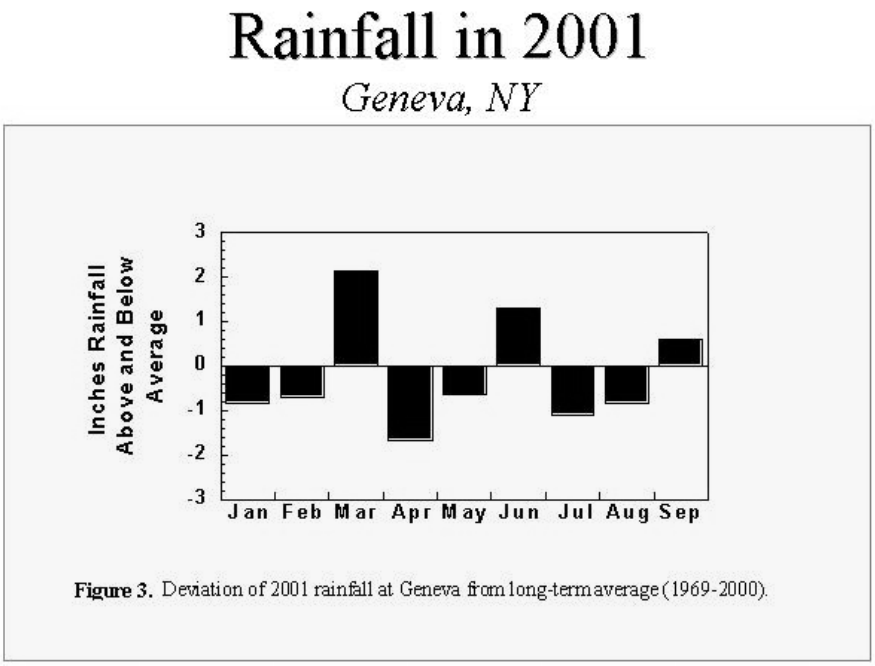
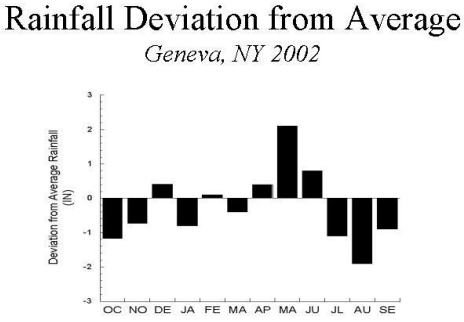
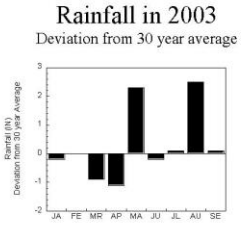


Figure 3. Deviation of 2001 rainfall at Geneva from long-term average (1969-2000).

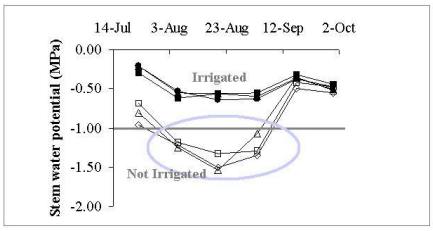




2. Stem water potential and leaf photosynthesis in 2002. In all three years, we measured water status of the leaves (leaf water potential, left) and leaf photosynthesis (right). In 2002, stem water potential dropped below –1 for about 6 to 8 weeks (left). –1 is about the threshold at which leaf stomates are fully shut during the day. As a result, direct measurements of leaf photosynthesis (right) were *very low* in comparison with irrigated vines. Water stress in 2002 shut down photosynthesis for seven weeks during the hottest months of the growing season. The data is from 2002, but we saw similar trends in 2001.

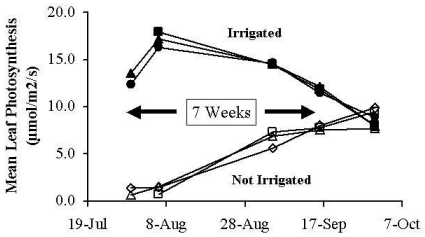
Stem Water Potential

Riesling Irrigation and N trial 2002



Leaf Photosynthesis

Riesling Irrigation and N trial 2002



3. Yield and Quality in 2001. There was no difference in yield in 2001, however irrigation increased berry weight by 0.1 gram, and clusters were heavier in the irrigated treatment (left). Brix (right) was 2 degrees higher in the irrigated plots. In other words: Irrigation increased berry size and brix simultaneously.

Yield Components At Harvest

Riesling Irrigation and N trial 2001

Treatments Irrig	N	Yield (lb/vine)		Berry Wt (g)	Berry# (#/cluster)		Cluster Wt (g)	Cluster # (#/vine)
No	0	10.6		1.58	55.7		87.7	54.5
	Foliar N	10.6	1.6	1.57	58.6	88	91.5	52.8
	Soil N	9.6		1.62	52.9		84.4	50.1
Yes	0	10.0		1.73	58.8		99.8	45.1
	Foliar N	8.3	1.7	1.74	54.9	98	95.2	38.7
	Soil N	11.5		1.75	56.5		98.2	53.1
Significance								
Irrigation		ns		P<0.01	ns		P<0.001	ns
N		ns		ns	ns		ns	ns

P values indicate the significance level. ns: non-significant.

Juice Analysis 2001

Soluble Solids and Yeast Available Nitrogen

Treatments Irrig	Nitrogen	Brix (%)	Yeast available N (mg/L)
No	0	20.3	180.9
	Foliar N	20.0	→ 277.1
	Soil N	20.2	168.9
Yes	0	22.8	→ 244.7
	Foliar N	22.1	→ 329.2
	Soil N	22.7	244.8
Significance			
Irrigation		P<0.0001	P<0.001
N		ns	P<0.001

P values indicate the significance level. ns: non-significant.

Riesling Irrigation and N trial 2001

4. Yield and Quality in 2002. In 2002, we saw similar trends, but more exaggerated than in 2001. Irrigation increased brix by 3 degrees, and berry size by 0.3 g (30%). Cluster number in both plots was similar. Irrigated vines had larger berries with higher sugar content. However, a side effect (below) was that the irrigated fruit had higher levels of fruit rots than unirrigated fruit. We think this may be related to the sunburning we saw in Riesling vineyards in September 2002.

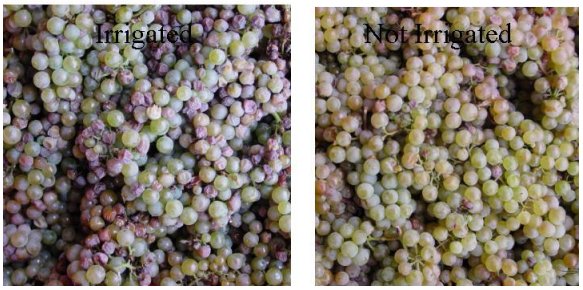
Yield Components at Harvest

Riesling Irrigation and N Trial 2002

Treatments Irrigation	N	Brix (%)		Yield (kg/vine)		Berry Wt (g)	Berry# (#/cluster)		Cluster Wt (g)	Cluster # (#/vine)
No	0	18.9		5.04		1.31	58.1		76.3	65.9
	Foliar N	18.5	**18.5**	5.42	**1.3**	1.36	56.5	**76**	77.0	70.1
	Soil N	18.4		5.78		1.33	56.5		74.9	76.5
Yes	0	21.7		5.57		1.82	42.8		77.9	72.1
	Foliar N	21.2	**21.5**	5.91	**1.7**	1.74	43.2	**76**	75.4	78.6
	Soil N	21.6		5.13		1.70	43.7		73.3	70.1
Significance (P)										
Irrigation		0.0001		ns		0.0001	0.0001		ns	ns
N		ns		ns		ns	ns		ns	ns

P VALUES INDICATE THE SIGNIFICANCE LEVEL. NS: NON-SIGNIFICANT.

Fruit Quality - 2002



5. Pruning Weights after 2002. Irrigated vines had twice the grown pruning weight at the end of 2002 as the unirrigated vines. Again, this was a consequence of the irrigated vines' ability to keep on photosynthesizing during the dry weather, when other vines shut down.

Pruning Weights 2002-2003

Treatments Irrigation	N	Pruning Wt (lb)
No	0	0.87
	Foliar N	1.17
	Soil N	1.10
Yes	0	1.89
	Foliar N	1.80
	Soil N	1.76
Significance (P)		
Irrigation		<0.001
N		ns

6. Yield and Quality in 2003. All plots had adequate soil moisture in 2003. Therefore any effects on yield were the result of carryover effects from the 2002 drought. Brix levels were higher in the 'unirrigated' blocks, but this was because they were carrying much less crop. Berry weight was also similar. However, yields in the 'unirrigated' blocks averaged 12 lb/vine in comparison with the 23 lb/vine in the 'irrigated' plots. Clusters were the same size in both

blocks, so the difference in yield was because of the different number of clusters – again the 'unirrigated' vines had about half the number of clusters as the irrigated vines.

Yield 2003

Table 3. Effects of irrigation and nitrogen applications on Riesling yield and Brix (2003)

Treatments Irrigation	N	Brix (%)		Yield (lb/vine)		Berry Wt (g)		Berry# (#/cluster)	Cluster Wt (g)		Cluster # (#/vine)
No	0	18.5		10.8		1.86		67.4	125.7		38.0
	Foliar N	18.3	**18.5**	14.4	**12.5**	1.87	**1.9**	68.9	128.6	**43.7**	50.0
	Soil N	19.0		12.5		2.04		63.4	129.1		43.2
Yes	0	17.4		26.1		1.92		66.4	127.4		92.4
	Foliar N	17.6	**17.5**	21.8	**23.3**	1.95	**1.9**	61.2	118.9	**84.7**	82.8
	Soil N	17.4		21.9		1.90		64.7	123.0		79.7
Significance (P)											
Irrigation		0.010		0.0001		ns		ns	ns		0.0001
N		ns		ns		ns		ns	ns		ns

Summary. During two drought years, water stress sharply reduced photosynthesis during July and August, and into September in 2002. Vines without irrigation had smaller berries with lower sugar content than irrigated vines in those years. Following a 7 week period of reduced photosynthesis in 2002, irrigation doubled the pruning weights as compared with unirrigated vines. This resulted in a large carryover effect in 2003. In an environment in which there was adequate water supply for all vines, the 'unirrigated' vines had half as many grape clusters, and produced half as many pounds per vine.

The difference in this case was at least two tons per acre for 2003, for a 'loss' of about $2800 in gross income per acre (at $1400/ton for Riesling). Add to that the cost in quality from having less ripe grapes during the two drought years, and the overall economic effect of not irrigating during a severe drought adds up to several thousand dollars. If you have a site with shallow, droughty soils of limited water holding capacity, losses of this magnitude would be more than enough to pay for installing an irrigation system in one year.

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