PROCEEDINGS
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GRAPE--WINE
SHORT COURSE

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CONTENTS

PREFACE

Approximately 130 persons attended the 1978 Ohio Grape-Wine Short Course which was held at the Fawcett Center for Tomorrow, The Ohio State University, Columbus, Ohio, on February 21-22. Those attending were from 10 states not including Ohio and represented many areas of the grape and wine industry. This course was sponsored by the Department of Horticulture, The Ohio State University, in cooperation with Ohio Agricultural Research and Development Center, Ohio Cooperative Extension Service and Ohio Wine Producers Association.

ROADSIDE MARKETING CONCEPTS

William J. Eyssen
Mapleside Farms, Inc.
Brunswick, Ohio 44212

When a table and umbrella goes up at the orchard or vineyard to sell our pro-
duce, we call it "roadside marketing". This gives the grower a means of selling
his farm products direct to the consumer at a higher markup than he could if he used
the wholesaler. We can move into many extremes with our "roadside vehicle" and
oftentimes we pass from roadside sales to "entertainment farming" or a combination
of both. But, we must all admit, our ultimate goal is to sell our products plus
other compatible produce lines.

Being a grower of apples, peaches, plums, pears, and nectarines seems to provide
a built-in promotional program of its own. Customers prefer to travel directly to
the source of supply where they seek to find freshness, variety, quality, and grade
of product plus added features tied down to what I call "entertainment atmosphere".
By this, I mean a trip to the "Apple Farm" often means being entertained by the
grading operation, making cider and apple butter, harvesting fruit, or just observ-
ing the beautiful array of fruit on the tree.

At our Mapleside Farm of 100 acres, outside suburban Cleveland and Akron, we
actually can promote our fruit products in many ways. We retail all of our 20,000
bushels of apples and other fruit and even buy more! Not only do we sell an apple
to the family from Cleveland, but they are also tantalized by 100 different kinds
of cheese in the Cheese House, the housewife is lured to the Flower House for a
beautiful gift, and the children can't escape the big ice cream cone in the Ice
Cream Parlor.

In the fall we encourage our customers to be present for our weekend celebration
of the "Johnny Appleseed Festival", where last year 10,000 people enjoyed the musi-
cal drama on our front lawn area. Balloons, an old fashion calliope playing happy
tunes, the apple butter making, free cider, and tours through our packing, storage,
and cider rooms brought out a few of the "built-in" features of harvest promotion.

At Christmastime, we at Mapleside invite our customers to view our 18 ft. Christ-
mas tree trimmed in popcorn and cranberries and to taste our delicious hot cider
served around the huge fireplace while they observe and order their Christmas gifts
of apples, cheese, maple syrup, fruit baskets, poinsettias, or Christmas arrange-
ments and gifts.

I feel that all this is promotion of our crop and promotion goes on long after
advertising has subsided. We are really promoting when we give an apple to the
drive-in window cashier at the local bank, when we schedule some 4000 children for
tours from November through March, present some 20 musical programs yearly on "Apples
Grown to Music", place apples on the football and basketball buses at away games,
be known as the "Apple Man" to thousands of customers, and open up our farm to an
apple blossom tour in the spring.

Advertising seems to have been a vehicle for our promotion at Mapleside. We
pay out from our budget about 3% of our gross to newspaper ads that "show and tell"
the farm line of products and what to expect in the Cheese House and Flower House
areas. We publish newsletters monthly for the customer to pick up in the store; we
also buy soft-sell radio ads heard three times a week. Newspaper ads help to promote

an image but sometimes it serves only as a reminder to people that we're still in business. The artistic use of color pictures of fruit on your truck costs initially but promotes continuously. A colorful brochure of our gift lines can excite our prospective customers in using our fruit as a possible year round gift for anniversaries, sickness, birthdays, congratulations, or a birthday gift. Whether it's the farm name on all our bags, baskets, labels, jugs, or merchandise, promotion of our product is evident.

At Mapleside Farms we like to "radiate" good horticulture practices both inside and outside our stores as we welcome our customers by the use of lovely flower beds and hanging pots displaying their colorful array of flowers and surrounded by meticulously well groomed lawns. We tie our customers to the tradition of our farm with the location of our original Johnny Appleseed Tree and our 200 year old marvelous, mighty oak tree both located in the north parking lot where all may admire their beauty and nostalgia.

We also feel that cleanliness of stores, parking lot, and orchard does much to set the "quality" image in our stores. Constant repainting, mopping, and updating our maintenance program as well as repairing that hole in the parking lot, keeps the customer positive in our attempts to sell an apple!

We have found that certainly the integrity of the grower is always at stake when he sells his fruit. The customer trusts our decision when we recommend a new variety of apples; he trusts our ability to grow crisp, juicy, disease-free, quality apples; he trusts our choice in the quality of other products not directly grown on our farm. It is with this same integrity that America has prospered over these 200 years by exercising our private enterprise system.

As grape growers and wine manufacturers, you also have a "built-in" promotion for "roadside marketing". A salesroom equipped with your own wines for sale, a wine tasting area opening up to a view of your vineyard provide a special "entertainment" to sales unequaled by any wine store outlet. A view of the large wine press and showing of the aging process of all wines in the large casks provide special sales atmosphere for the final purchase of your product. Special unique areas for Cheese sales, home baked pies, and a view of your gift line could also stimulate sales at the vineyard and add outside money to your pockets. What about "Ohio" wines on airline trips instead of California wines?

In conclusion, I feel we must remove our "blinders" and observe the many areas that we as growers have "built-in" for us. The excitement of promoting a new crop should be shared by all people near and far if we are to succeed as growers.

BUILDING A SMALL WINERY

Ken Schuchter
Valley Vineyards
Morrow, Ohio 45152

My talk is based on the cost of building, from scratch, a structure that will allow you to operate a 20,000 gallon winery. It is my belief that anyone who has planted any quantity of grapes (5 or more acres) in the last 10 years has has a desire to own and operate his own winery. If you haven't had this feeling, then you should get it, because you are really missing the fun part and the profitable end of growing grapes. Probably the two main reasons more small wineries are not being started is because of the cost and lack of knowledge of operating a winery. If we can do it, anyone can. It just takes dedication and hard work.

Most anyone can afford to build a winery. Making a success of it comes under how to operate it. This takes more time than we have here today to explain.

Due to the growth in our business and the wine festival, in the spring of 1976, we started building a structure that would give us seating capacity of an additional 100 people. While we needed only the extra seating capacity, we thought we would also excavate under the proposed site and build a new and additional wine cellar. As a bonus, we also have a second floor which we use for private parties, wedding receptions, and overflow crowds.

Before we started building this structure, we decided we wanted to incorporate certain things we thought were important. We obtained ideas by taking a six-day trip to various wineries, both large and small throughout Ohio, Pennsylvania, New York. At each place, we picked up ideas, good and bad, as to what special things made these wineries successful or future failures. I would like to say right here that people were the most important factors that I found in the successful operation of a small winery.

The following points were noted and should be followed:

    1. SITE: Near some large city (30 miles)
    2. BUILDING: Attractive and different
    3. LANDSCAPING: Attractive
    4. WINE CELLARS: Clean, light and organized
    5. ENTRANCE SIGN: Large and denotes winery
    6. LIGHTING: Building well lighted at night
    7. TASTING ROOM: Interior clean, attractive different
    8. HOSTESS: Attractive and knowledgeable
    9. SPECIAL FEATURE: Personalizing labels, Blue Eye Wine, etc.
   10. GOOD WINE IN SUFFICIENT QUANTITIES

The total cost of Valley Vineyard's new building amounted to $61,812 and is 5,400 square feet.

This is broken down as follows:

MATERIAL	25,578.00
LABOR	11,497.00
HEATING, AIR CONDITIONING, ELECTRONIC FILTERS	10,856.00

ELECTRIC	7,085.00
MISCELLANEOUS	6,796.00

All labor, except my brother, my son, and myself were included. We did haul most of the material used. We shopped prices on everything except labor. We did not get anything inferior, and if you see our building, you would say we went just the opposite. This was built during our busy time, spring and summer. We could have spent two times the money we spent if we did not work at getting it done at a better price.

Our main tasting room is 55' by 27' (2700 square feet) and will seat 125 people. We used paneling from an old barn. We have two restrooms, both of nice size; insulation is liquid foam, full 3 1/2". The upstairs is 55' by 21' (2100 square feet) and fully carpeted, the walls are wallpapered with a grape design paper. The cellar is 55' by 27' (1500 square feet), all cement with eight-inch sides and six-inch floor. It has two storage areas (160 square feet) for bottle aging. The cellar will hold 48 stainless steel tanks, capacity of 26,000 gallons. There is an outside, roofed and cemented, crushing and pressing area.

In comparison, the following information was given to me by new small wineries: Senator Buz Lunken, Harveysburg, Ohio - 1,200 square feet, capacity of 2,500 gallons, cost $12,000 to build. Brushcreek Vineyards, Peebles - 1,700 square feet, capacity 5,000 gallons, cost $9,000. Wally Zins and Ed Stefano, near Dayton - 2,400 square feet, capacity 2,500 gallons, cost $10,000. Norm Greene, Colonial Vineyards, Lebanon - 2,400 square feet, capacity 10,000 gallons, cost $14,000.

I just want to point out that most anyone who seriously wants to start a winery can afford to do it. Anyone who has a winery will be glad to advise and help out. We hope to see many more successful wineries in Ohio.

EQUIPPING A SMALL WINERY

Anthony P. Debevc
Chalet Debonne Vineyards
Madison, Ohio

I would like to impress upon you that a partnership of 2 or 3 individuals can construct and operate a small modern winery in Ohio, with a reasonable investment. With proper management and quality product, this initial investment can also be repaid in a relatively short period of time--4 to 5 years.

Before your dream of owning a winery is to begin, however, all individuals must face two vital criteria, dedication to the business's welfare plus a continuous drain of thought and physical work to meat your goal--"a successful and prosperous operation." Available finances are the only factor that will adjust these two criteria; (i.e. the greater the monies available during the first two critical years, the less mental and physical drain there is on the partnership).

The selection and present day costs of equipment are important factors. However, certain guidelines must be drawn first. The operator should be strictly agricultural (i.e. over 50% of your raw product should come from vineyards operated by the winery). This alone eliminates many expenses and headaches such as permits, workmans' compensation, personal property tax, etc. Two lists of equipment should be made--one for a 10,000-gal./yr. winery and one for a 20,000 gal./yr. winery. All prices for equipment should be for new machinery that is more than adequate until prosperity is obtained. Fifty percent of the wine should be white and 50% red wine. Since there are many ways of equipping a winery, I will describe those which have proved successful and practical for Valley Vineyards and Chalet Debonne Vineyards.

In order to have an efficient and profitable operation, one must obtain an annual sales level of approximately 20,000 gal./yr. However, it will take a few years to obtain sales at that level. Emphasis must be placed on producing a smaller amount of quality wine the first couple of years. This will allow time to perfect your techniques and could prove less costly in what can be described as a "trial and error method" when venturing into this new business. If monies are not as critical, professional help is available but can prove very expensive and less secure, especially if the professional help is lost. Who will make the wine when your winemaker quits? However, a new man often brings in new ideas and techniques.

Prices are for two different size wineries, which are for valid financial reasons. Unless your operation is heavily financed, developing a market is very time consuming and expensive, taking at least 2 to 4 years to develop at best. I suggest starting with equipment that will operate a 10,000-gal. winery. This equipment will prove useful later on as things progress and will always return your investment if sold in good condition.

It is a ridiculous waste of finances to purchase equipment that will not be used to its capacity for 3 or 4 years. That money would be better spent in more vital areas of your operation. Be conservative until your winery can afford the extravagant equipment available to the winemaker!

Greater demand than supply is a problem anyone can live with but the reverse can prove devastating.

Prices quoted as of January 1, 1978

<u>10,000 Gallon</u>	<u>20,000 Gallon</u>
1. 1 ton press - $5,000-8,500	1 ton press - $5,000-8,500 2 ton press - $9,000-13,000
2. Crusher-Stemmer - $500-1,500	Crusher-Stemmer - $750-2,500
3. Open Fermentation Vats (1,200-1,500 gal. total usable) (vats-fiberglass) $1,200-1,500	Open Fermentation Vats (2,500- 3,000 gal. usable) (vats-fiberglass) $2,400-2,800

4. Stainless steel storage tanks
(for 10,000 gal. winery which
is impractical to purchase all
at once)
   6,000 gal. 1st yr. $7,500
   5,000 gal. 2nd yr. $1,200
	Stainless steel storage tanks
	(for 20,000 gal. winery which
	is impractical to purchase all
	at once)
	   11,500 gal. 1st yr. $14,500
	   10,000 gal. 2nd yr. $12,500

5. 50 gal. American Oak Barrels
($12.00 each)
   6,000 gal. 1st yr. $1,440
   5,000 gal. 2nd yr. $1,200
	50 gal. American Oak Barrels
	($12.00 each)
	   11,500 gal. 1st yr. $2,760
	   10,000 gal. 2nd yr. $2,400

6. Barrel Racks (wood) 120 barrels 1st yr. $450-500 100 barrels 2nd yr. $350-400	Barrel Racks (wood) 230 barrels 1st yr. $820-920 200 barrels 2nd yr. $700-800
7. Used Hand Forklift - $100-200	Used Hand Forklift - $100-200
8. Mixing Tanks 500-750 gal. total $250-900	Mixing Tanks 1,500-2,000 gals. $500-2,200
9. Corker (hand) - $600	Corker (semi-automatic) $2,000-3,200
10. Gravity Filler (6 spout) $500-700	GGravity Filler (8 spout) $700-900
11. Bottling Tank $200-250	Bottling Tank $400-500
12. Labeler - $300-500	Labeler - $750-2,000
13. Capsuler - $500-600	Capsuler - $500-2,500
14. Filter (10-12 plates) $1,800-5,000	Filter (20 plates) $2,200-6,000
15. Positive Displacement Pump (for filtering) $500-1,000	Positive Displacement Pump (for filtering) $1,000-2,500
16. 2 Transfer Pumps - $300	2 Transfer Pumps - $500
17. Hoses (3/4") & fittings $200-300	Hoses (1" & 3/4") & fittings $400-500

	10,000 Gallons		20,000 Gallons

	10,000 Gallons	20,000 Gallons
18.	Wash Sink - $250-500	Wash Sink - $250-500
19.	Winemaking Supplies (locks, stoppers, bungs, etc.) $200-300	Winemaking Supplies - $400-600
20.	Chemicals (meta, SO_2 stick, soda ash, baking soda) $150	Chemicals - $150
21.	Laboratory Equipment - $200-300	Laboratory Equipment - $300-500
22.	Pallets, shelving - $100-250	Pallets, shelving - $250-500
23.	Misc. hand tools & equipment $0-500	Misc. hand tools & equipment $0-500
24.	Options - grapes, sugar, etc. as needed - cost?	Options - grapes, sugar, etc. as needed - cost?

	10,000 Gallons		20,000 Gallons	
1st year	$22,240	$33,290	$45,630	$65,970
2nd year	7,800	7,850	15,600	15,700
	$30,040	$41,140	$61,230	$81,670

Equipment quoted by:

Boordy Vineyards
Box 38, Riderwood, Maryland 21139

Hubert C. Stollenwerk
Egg Harbor City, New Jersey 08215

Budde & Westermann
151 Forest Street, Montclair, New Jersey 07042

SWK Machine
47 West Steuben Street, Bath, New York 14810

Local Suppliers

GRAPE-WINE RESEARCH PROGRAM IN ONTARIO

Richard V. Chudyk
Horticultural Research Institute of Ontario
Vineland Station, Ontario, Canada LOR 2E0

Statistics and Trends

In Ontario, the area devoted to grape production has gradually increased over the past twenty-five years. In 1976, there were 9448 hectares of grapes occupying 32.5% of the total fruit land.

The recent census indicates there are 1241 grape farms in Ontario, 97% of which are situated in the Niagara Peninsula. Since 1971, the total number of grape farms has decreased. At the same time, the number of large farms has increased while the number of small farms has decreased.

The total farm value for Ontario grapes in 1976 was $16,642,000 or 25% of the total farm value for all Ontario-grown fruit. Grapes were, therefore, second to apples which constituted 38% of the total farm value for all Ontario-grown fruit.

In 1976, Ontario's grape production was 72,560 metric tons, 67% of which was purchased by processors.

A factor that has a major effect on Ontario's grape industry is the sale of Ontario wines. In the early 1970's, Ontario's wines enjoyed a strong market position throughout Canada. However, the establishment of wineries in non-grape growing provinces has decreased the sale of Ontario wines in other provinces. The Ontario industry has had to rely on Ontario as the principle market for its wines. At one time, Ontario wines dominated the Ontario market. However, in recent years, the increasing demand for table wines had resulted in increased sales of foreign table wines. This very shift towards table wine consumption has resulted in some changes in the direction of the Ontario industry.

Table 1 shows the classification of Ontario-grown grapes by processing classes. Over the past twenty years, there has been a definite shift in the types of grapes grown. Grapes in classes 1-4a are generally the traditional North American varieties. Classes 5-10 constitute the preferred varieties for making wines with vinifera-like character. In 1957, 87% of the vines were in Classes 1-4a while only 13% were in preferred Classes 5-10. The most recent census shows a definite trend towards Classes 5-10. In fact, in 1975, 34% of the vines in Ontario belonged to Classes 5-10. Clearly, in Ontario, there is shift towards growing grapes that produce table wines with vinifera-type character.

Research Trends

There has been a broad based grape and wine research program in Ontario for many years. In fact, varieties such as DeChaunac were introduced into variety evaluation trials in the late 1940's. Research by industry as well as the Horticultural Research Institute of Ontario has led to the widespread planting of DeChaunac. In fact, DeChaunac is now the third most widely grown grape variety in the province (Table 2).

In view of the increasing demand for table wines, the main thrust of grape and wine research in Ontario is to provide a significant increase in production of grapes

TABLE 1. Classification of grapes by processing classes

Class	Varieties
Class 1	Concord, Fredonia, Patricia, Van Buren, Clinton, Lincoln, Lomanto, Beta, and Westfield.
Class 2	Elvira, Missouri Riesling, Buffalo, Seneca and Ontario.
Class 3	Niagara.
Class 3a	Agawam, Brighton, Vergennes, Diana and Caco.
Class 4	Veeport, V. 35122 and V. 35123.
Class 4a	Catawba and Ventura.
Class 5	Blue French Hybrids, Seibel 7053, S. 1000, S. 10878, S. 13053, Baco, J.S. 26-205 and DeChaunac.
Class 6	Delaware, Dutchess, Foch, N.Y Muscat, Canada Muscat, Alden and Vincent.
Class 7	White French Hybrids, Seibel 5279, S. 8229, S. 9110, S. 10868, S. 13047, Seyve-Villard 172, S.V. 5276 and Vidal 256.
Class 8	Couderc 29935, B.S. 2862, Seibel 8357 and B.S. 2846.
Class 8a	President.
Class 9	Vinifera varieties.
Class 10	Experimental varieties.

TABLE 2. Grape cultivars in Ontario -- 1976

Variety	No. of vines	% of Total
Foch	523,231	3.73
Fredonia	601,790	4.29
Elvira	914,024	6.51
Rosette (S. 1000)	104,198	0.74
DeChaunac (S. 9549)	1,274,715	9.08
Delaware	589,886	4.20
Chelois (S. 10878)	428,843	3.06
New York Muscat	106,817	0.76
President	181,730	1.30
Niagara	1,599,105	11.40
Ventura (V. 51061)	135,845	0.97
Veeport	158,313	1.13
Concord	4,720,090	33.63
Vincent	67,635	0.48
Agawam	720,234	5.13
Le Commandant (B.S. 2862)	167,174	1.19
Canada Muscat	66,196	0.47
Catawba	479,077	3.41
Dutchess	323,145	2.30
Verdelet (S. 9110)	67,766	0.48
Pinot Chardonnay	69,797	0.50
Other varieties	734,645	5.24
Total	14,034,256	100.00

with vinifera-type characteristics. This is done mainly through breeding as well as the importation and evaluation of material bred elsewhere.

The grape breeding program at Vineland has made significant progress over the years. In the early crosses, high sugar levels were hard to come by. Table 3 summarizes the sugar levels of some of the Vineland material. While early crosses were not always high in sugar, the average sugar levels in crosses since 1962 has exceeded 18.0° Brix.

Table 4 summarizes the acid levels of some of the Vineland material. The traditional complaint against grapes grown in North Eastern North America is that they are too high in acid. There are now approximately 120 Vineland hybrids with acid levels (TA) between 0.71 and 1.30.

Figures 1 and 2 present the juxtaposition of sugar and acid levels for red and white hybrids, respectively. Clearly, the Vineland breeding program under Mr. O.A. Bradt has yielded some promising high sugar-low acid grapes for making table wines.

Veeblanc--Ontario's Newest Wine Grape

A good example of a high quality table wine grape is the new variety Veeblanc developed at Vineland. Veeblanc is a white vinifera-type grape developed from two French hybrid parents (i.e. Seibel 13052 x Seyve-Villard 14287). This new variety can provide the Ontario industry with high quality vinifera-type table wine. Over the years, Veeblanc has produced high sugar levels (18.0°Brix) as well as low acid levels (0.87 Total Acid). This new variety is gaining momentum in Ontario and is now out under large-scale grower trials. Veeblanc is an excellent example of how research and development has assisted the grape and wine industry to respond to the changing demands of the wine market.

TABLE 3. Summary of sugar levels in existing Vineland bred selections.

Breeding series by year	Mean	Min.	Max.	No. selections retained	Number of hybrids at various sugar levels									
					13.1-14.0	14.1-15.0	15.1-16.0	16.1-17.0	17.1-18.0	18.1-19.0	19.1-20.0	20.1-21.0	21.1-22.0	22.1+
1929	14.8	--	--	1										
1935	17.5	14.8	19.3	4		1			1	1	1			
1937	17.2	16.9	17.8	4				2	2					
1949	16.0	13.8	18.9	5	1	1			2	1				
1950	17.1	15.1	18.1	11			1	4	5	1				
1951	17.9	15.6	21.5	4			1	1	1				1	
1952	15.6	14.1	16.9	10		3	3	4						
1953	17.2	15.6	18.9	11			2	3	2	4				
1954	17.1	14.9	19.9	12		1	1	6	1	2	1			
1958	16.7	15.0	18.0	5		1		2	2					
1960	16.8	15.7	18.0	2			1		1					
1961	16.5	16.2	16.8	3				3						
1962	18.7	18.1	19.3	2						1	1			
1963	19.0	15.7	21.1	14			1	1	2	3	2	4	1	
1964	18.7	15.7	21.4	25			1	3	6	3	6	4	2	
1965	20.5	17.2	22.3	38					2	2	6	12	13	3
1966	19.1	18.6	19.6	2						1	1			
1967	21.8	18.4	26.1	21						2		7	6	6
1968	20.0	--	--	1							1			
1971	18.1	--	--	1						1				
		TOTAL		176	1	8	11	29	27	22	19	27	23	9

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TABLE 4. Summary of acid levels in existing Vineland bred selections

Breeding series by year	Mean	Min.	Max.	No. selections retained	Number of hybrids at various sugar levels										
					0.11-0.30	0.31-0.50	0.51-0.70	0.71-0.90	0.91-1.10	1.11-1.30	1.31-1.50	1.51-1.70	1.71-1.90	1.91-2.10	2.11-2.30
1929	1.13	--	--	1						1					
1935	0.90	0.39	1.19	4		1			2	1					
1937	1.04	0.80	1.33	4				2		1	1				
1949	1.11	0.88	1.15	5				1	1	3					
1950	1.37	0.84	1.71	11				1		2	5	2	1		
1951	1.06	0.70	1.33	4			1		1	1	1				
1952	1.25	0.91	1.69	10						4	2	2	2		
1953	1.05	0.63	1.61	11			1	4	3	1		2			
1954	1.05	0.54	1.74	12			1	3	4	2	1		1		
1958	0.89	0.50	1.19	5		1	1	1		2					
1960	1.27	1.06	1.48	2					1		1				
1961	0.78	0.41	1.01	3		1			2						
1962	0.59	0.56	0.62	2			2								
1963	0.99	0.17	1.48	14	1		1	4	2	4	2				
1964	0.98	0.63	1.36	25			3	7	6	8	1				
1965	0.92	0.48	1.51	38		1	10	10	7	5	4	1			
1966	0.77	0.52	1.02	2			1		1						
1967	1.15	0.75	2.30	21				8	6	2	1	2		1	1
1968	1.19	--	--	1						1					
1971	0.79	--	--	1				1							
		Total		176	1	4	21	42	40	36	19	9	2	1	1
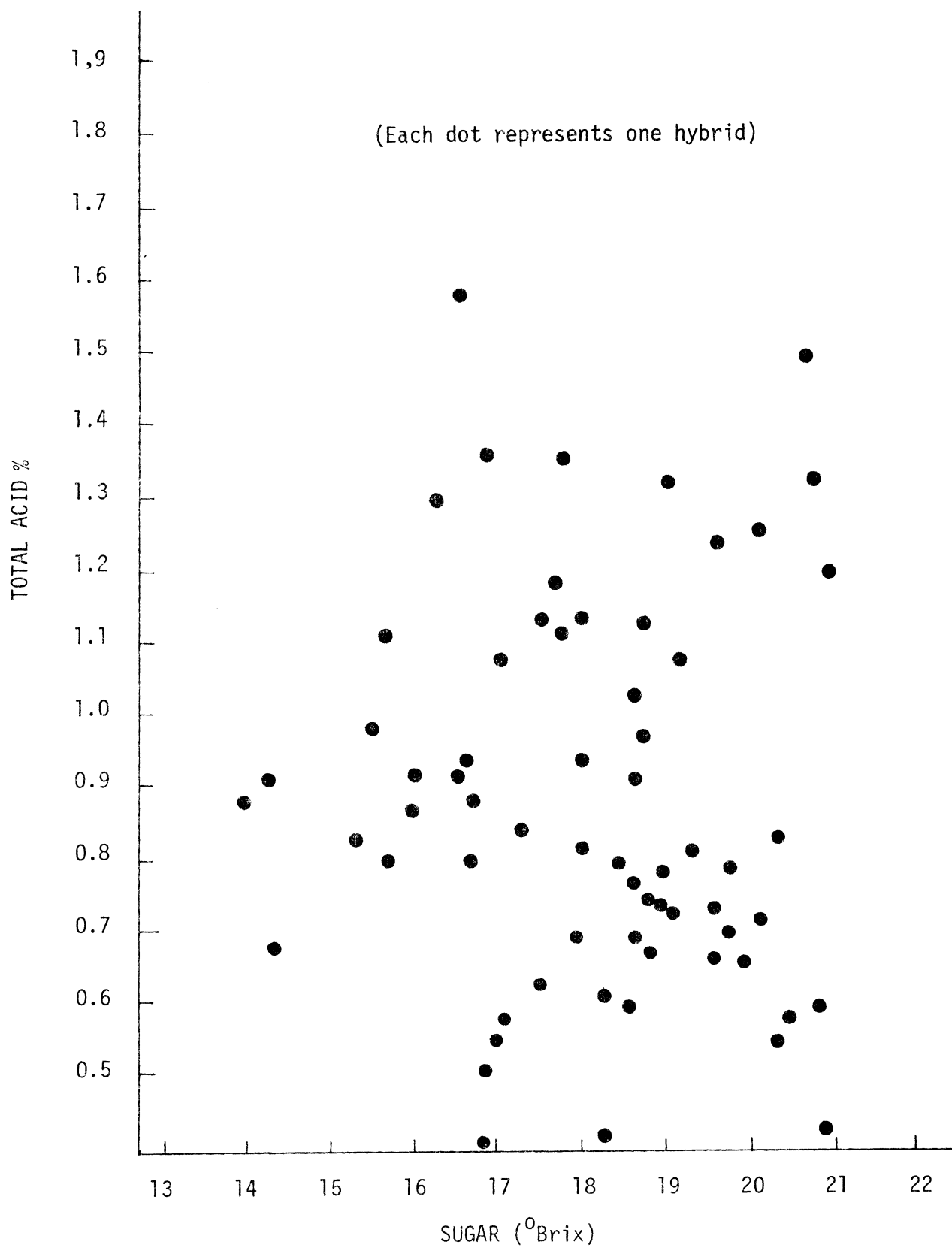
Fig. 1 Sugar and acid in <u>white</u> Vineland hybrid grapes.

TOTAL ACID %

1.7

1.6

1.5

1.4

1.3

1.2

1.1

1.0

0.9

0.8

0.7

0.6

0.5

(Each dot represents one hybrid)

13   14   15   16   17   18   19   20   21   22
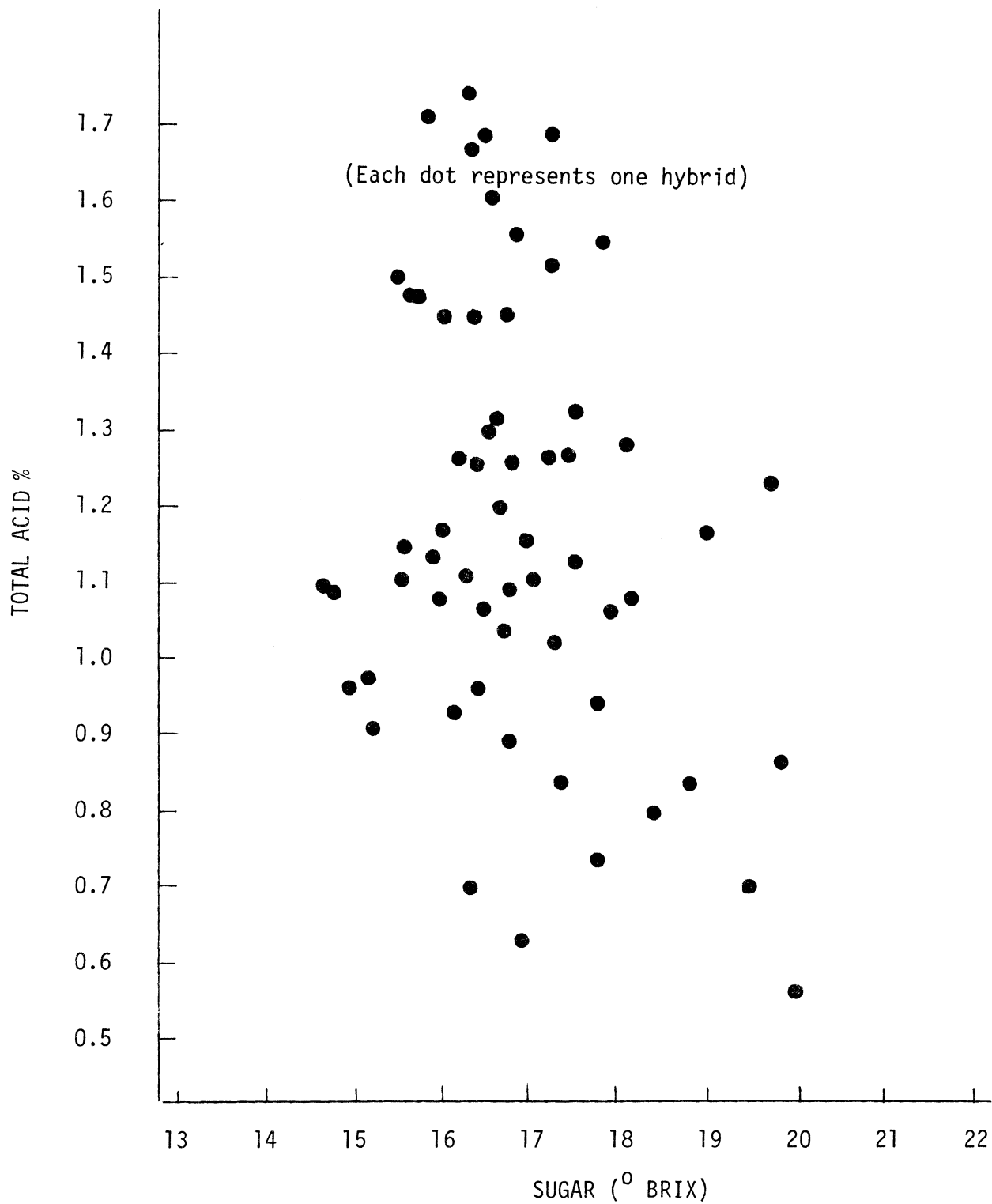
SUGAR (^{O} BRIX)

Fig.2   Sugar and acid in red Vineland hybrid grapes

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EVAULATION OF GRAPE VARIETIES AND
SELECTIONS FOR OHIO TABLE WINES

J. F. Gallander and J. F. Stetson
Department of Horticulture
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The evaluation of grape varieties and selections for wine has been in progress for several years at the OARDC (2,3,4,5,6). The grapes used in this study have been grown at the OARDC Southern Branch near Ripley. Although the fruity "labrusca" quality of classic Catawba, Delaware, Niagara, and Concord wines is still popular, the Ohio wine industry has expressed interest towards producing high quality table wines with more neutral flavor and aroma. These type wines, along with established labrusca wines, would afford the Ohio wine industry the opportunity to maintain and strengthen its position in an expanding wine market. For this reason, this study was concerned mainly with those varieties and selections which produce high quality wines without labrusca character.

This report is concerned with the evaluation of those varieties and selections harvested during the 1976 season. This season was not typical, because yields from most of the grapes were too low for making wine. Cahoon (1) reported that spring frosts did considerable damage to the fruit yields.

Procedure

Each grape was harvested at maturity and transported to the OARDC Department of Horticulture in Wooster for wine production. The grapes were destemmed, crushed, and transferred to stainless steel or glass containers. A representative must sample was obtained and analyzed as follows:

1. pH: The pH was determined by the glass electrode method (Corning Digital 112 Research pH Meter), using grape juice of each variety.

2. Total Acids: A 10-ml. grape juice sample was titrated with a 0.1 normal sodium hydroxide solution to a pH of 8.2. The percent total acids was calculated as tartaric.

3. Total Soluble Solids: The soluble solids content was determined by using the Abbe refractometer.

From the soluble solids reading (an indication of sugar content), the amount of sugar needed to bring the original soluble solids content of each variety to 21% was calculated. The required amount of sugar (sucrose) was added and dissolved in the crushed grapes. Then the musts were treated with 100 ppm of sulfur dioxide in the form of potassium metabisulfite (57.6% sulfur dioxide).

The must from white grapes was immediately pressed, and the juice was ameliorated with 21% sugar syrup to 15% of the resulting volume. Then the juice was transferred to glass carboys and an active yeast culture was added to the juice, 1% by volume, 6 hours after the sulfur dioxide treatment.

For the red, blue, and black grapes, the musts were inoculated with an active yeast culture (1% by volume) 6 hours after the sulfur dioxide treatment. The fermenting crushed grapes were stirred twice daily and were pressed approximately 4 days

after the yeast was added to the musts. The fermenting juice was ameliorated with 21% sugar syrup to 15% of the resulting volume and transferred to glass carboys.

All carboys were equipped with water seals and were placed in 65°F. storage for fermentation. The fermentations were essentially completed in 4 weeks, and the wines were racked to clean glass carboys at this time. After additional rackings (over a 6-month period), the wines were placed in cold storage (30°F.) for approximately 3 weeks to precipitate the excess tartrates. The wines were racked, bottled, and placed back into 65°F. storage. After 1 month of storage, they were analyzed for composition and quality. The following chemical constituents were determined:

1. pH: The pH was determined by the glass electrode method (Corning Digital 112 Research pH Meter), using wine of each variety.

2. Total Acids: The wine was titrated with a 0.1 normal sodium hydroxide solution to a pH of 8.2. The percent total acids was calculated as tartaric.

3. Alcohol: The alcohol content was determined by using an ebullioscope, Dujordin-Salleron type.

4. Tannin: The tannin content was determined by using the standard (Pro) procedure.

Discussion of Results

The results of the chemical analyses for each of the various grape musts are shown in Table 1. The pH of the must samples varied between 3.04 (Vidal 256) and 3.39 (S.V. 23410). The total acids varied widely, with S.V. 23410 having the lowest percent, 0.60%, and Ravat 51, having the highest percent, 1.34%. The varieties and selections highest in percent soluble solids (sugar) were: S.V. 23512 (19.3%), Catawba (19.1%), Cabernet Sauvignon (19.0%), and Ravat 51 (19.0%).

The analytical data of the composition of the wines are summarized in Table 2. The Vitis vinifera Cabernet Sauvignon was highest in pH, 3.66, while the French hybrid Vidal 256 was lowest, 3.03. The results of the total acidity indicated that the wines varied widely, with a range between 0.50% (S.V. 23410) to 1.09% (Catawba). A total acidity level of approximately 0.65% is an acceptable value for most table wines. The overall average for the alcohol was 11.9%. The wines highest in tannin content were: S.V. 18315 (102.5 mg per 100 ml) and Landot 244 (92.5 mg per 100 ml). The tannin content is associated with the astringency of the wine.

In addition to the analytical results, Table 2 includes brief statements of the sensory examination of the wines. The results of this study and previous investigations including vineyard performance indicate that Baco noir, DeChaunac, Chancellor, Aurora, Villard blanc, Seyval, and Vidal 256 were best for making more neutral type wines. Other grapes that have shown potential in producing very good wines were: S.V. 12327, S.V. 18315, Ravat 51, Seibel 10868, and S.V. 12309. These selections have not been placed in the previous list because their performance has not been as consistent. Other grapes that yielded very good wines were GW-10 and Cayuga White (GW-3). However, these varieties have been evaluated for only two seasons; therefore, cannot be recommended at this time. For making the fruity labrusca type wines, the Standard American varieties are recommended, such as Catawba, Niagara, and Delaware.

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TABLE 1.--Must Analysis of Several Grape Cultivars - 1976 Season
OARDC, Wooster, Ohio.

Cultivar	Harvest Date	Color	pH	Total Acidity%	Soluble Solids %
Cabernet Sauvignon	9/15	Blue	3.16	1.02	19.0
Catawba	9/24	Red	3.17	0.99	19.1
GW 3 (Cayuga White)	9/1	White	3.06	1.06	18.8
Landot 244 (Landal)	9/9	Blue	3.32	1.11	16.5
Ravat 34	9/1	White	3.27	1.00	18.7
Ravat 51 (Vignoles)	9/1	White	3.05	1.34	19.0
S.V. 5276 (Seyval)	9/1	White	3.06	1.24	18.2
S.V. 12309 (Roucaneuf)	9/24	White	3.17	1.04	16.9
S.V. 18283	9/15	Blue	3.30	0.94	18.0
S.V. 18315 (Villard Noir)	9/9	Blue	3.11	1.32	16.6
S.V. 23410 (Valerien)	9/15	White	3.39	0.60	18.0
S.V. 23512	9/1	White	3.07	0.93	19.3
Vidal 256	9/24	White	3.05	1.18	18.2

TABLE 2.--Wine Analysis of Several Grape Cultivars - 1976 Season, OARDC, Wooster, Ohio

Cultivar	pH	Total Acids %	Alcohol %	Tannin mg/100 ml	Sensory remarks
Cabernet Sauvignon	3.66	0.72	11.6	80.0	Med. red, slightly distinct, good aroma, good
Catawba	3.11	1.09	10.8	65.0	Light orange, labrusca, slightly rough, fair
GW 3 (Cayuga White)	3.10	0.82	12.4	31.0	Med. yellow, clean, nice aroma, very good
Landot 244 (Landal)	3.57	0.86	11.6	92.5	Dark red, slightly fruity, rough, good
Ravat 34	3.23	0.73	12.4	30.0	Med. yellow, vinous, bitter, fair
Ravat 51 (Vignoles)	3.15	0.86	12.4	33.0	Med. yellow, tart, slightly fruity, good
S.V. 5276 (Seyval)	3.09	0.92	12.4	24.0	Med. yellow, neutral, tart, slight fruity good.
S.V. 12309 (Roucaneuf)	3.23	0.68	11.4	25.0	Light yellow, vinous, thin, slightly bitter, fair.
S.V. 18283	3.56	0.83	11.6	75.0	Dark red, poor flavor and aroma, poor.
S.V. 18315 (Villard noir)	3.42	0.98	12.7	102.5	Dark red, vinous, tart, thin, fair.
S.V. 23410 (Valerien)	3.28	0.50	12.2	21.0	Med. yellow, clean, slightly fruity, good
S.V. 23512	3.47	0.60	11.8	24.0	Med. yellow, vinous, slightly bitter, fair
Vidal 256	3.03	0.77	11.0	26.0	Med. yellow, neutral, bitter, little thin, fair to good

GRAPE CULTIVARS FOR WINE

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In keeping with the program from previous years, evaluations were made on the various cultivars of grapes under test at the Ohio Agricultural Research and Development Center. The most extensive investigations continue to be those at the Southern Branch in Ripley, Ohio. Average yield and maturity for 1977 is presented in Table 1. As was the case in 1976, yields of many of the cultivars were very low. However, the reasons for these low yields were both from cold winter temperatures and spring frosts. The 1977 season was one of the coldest in many years. Temperatures colder than -20°F were experienced. Spring frosts in late April and early May followed above average temperatures in March and April.

Notable among the cultivars that produced a normal or near normal crop were: Concord, Minnesota 40, Oklahoma 387, Ravat 34, S.V. 18315 and Moored (VPI 26), (Table 1).

As summer progressed, growing conditions were quite favorable, although rainfall was spotty during May and June. In late summer, excessive rainfall caused additional problems. As a whole, maturity was poor due to the rainfall and absorption of excess moisture. Some selections never did attain satisfactory soluble solids even though yields were low. Fruit of the cultivar Aurora was damaged to the extent that no harvest records were obtained.

Due to the cold winter temperatures, the series of <u>Vitis vinifera</u> cultivars were killed or very severely damaged. These cultivars were pulled in mid-summer.

1977 Average Yield and Maturity Data for Grape Cultivars at Southern Branch, OARDC, Ripley, OH

Cultivar	Plant date	Harv. date	Color	Yield/ vine	Cl. wt.	Cl. no.	# Vines/ avg.	% Sol. solids	% T.A.	Av. Pr. Wt.
Ark. 1019	1970	8/30	B	1.4	.18	7.3	4		----	
Ark. 1023	1972	8/30	R-B	3.3	.13	25.7	4	13.6	.39	1.7
Ark. 1163	1970	8/30	R	2.8	.21	13.5	4		----	
Catawba	1971	9/9	R	8.6	.25	34.7	20	16.5	.46	2.6
Concord	1970	9/19	B	23.8	.25	93.5	20	14.6	----	3.1
GR8	1973	8/24	W	7.0	1.1	6.5	1	17.3	.60	.42
GW3	1972	8/30	W	3.5	.19	18.2	5	14.0	1.07	2.9
GW5	1972	8/24	W	3.4	.16	20.6	6	16.5	----	1.8
GW8	1972	8/24	W	7.0	1.1	6.5	1	17.3	----	.65
GW10	1972	8/16	W	4.8	.23	20.8	5	17.2	----	1.07
Himrod	1971	8/11	W	5.5	.31	17.7	20	16.8	----	2.9
JS 26627	1972	8/30	W	9.2	.20	44.0	5	16.0	----	.50
Landot 244	1969	8/17	B	3.8	.25	15.0	6	14.6	1.11	.38
Minn. 40	1974	8/16	W	20.5	.22	91.1	6	14.6	----	1.6
Minn. 439	1974	8/24	W	6.5	.20	31.6	5	15.4	.54	1.1
Mo. 133	1974	8/24	-	2.2	.09	24.3	3	18.4	----	.25
NC 645-122-24	1974	8/30	-	4.2	.32	13.0	1	14.8	1.22	
N.Y. Muscat	1972	8/24	B	2.1	.29	8.6	3	16.8	.43	1.3
Okla. 211	1974	8/30	B	1.6	.13	12.0	3	15.3	.78	.23
Okla. 220	1974	9/14	B	6.9	.20	34.4	5	14.4	1.03	1.2
Okla. 229	1974	9/14	B	14.7	.28	51.0	4	14.3	.29	3.6
Okla. 249	1974	8/24	W	4.5	.20	21.8	6	15.0	.45	.47
Okla. 303	1974	8/24	R	4.2	.32	12.8	6	16.8	.70	.64
Okla. 324	1974	9/14	B	.7	.09	7.6	3	15.0	----	.94
Okla. 353	1974	9/14	B	5.2	.17	31.3	6	14.8	.72	2.3
Okla. 376	1974	8/24	B	2.0	.10	19.0	3	14.3	1.09	.13
Okla. 387	1974	9/14	B	18.5	.23	79.3	6	12.9	.62	1.6
Okla. 392	1974	9/14	B	16.3	.19	83.6	6	12.5	----	1.8
Okla. 395	1974	8/30	W	14.3	.29	49.3	6	15.1	----	1.1

1977 Average Yield and Maturity Data for Grape Cultivars at Southern Branch, OARDC, Ripley, OH (cont.)

Cultivar	Plant date	Harv. date	Color	Yield/ vine	Cl. wt.	Cl. no.	# Vines/ avg.	% Sol. solids	% T.A.	Av. Pr. Wt.
Ravat 34	1969	8/17	W	21.3	.26	80.2	9	14.7	----	1.8
Ravat 51	1969	8/17	W	7.6	.19	39.0	8	18.5	----	1.8
Seibel 7053	1973	8/24	B	3.3	.25	13.0	3	15.6	.81	1.1
Seibel 9549	1970	8/30	B	10.0	.14	72.9	20	18.0	----	4.4
Seibel 10868	1973	8/27	W	15.5	.14	81.7	14	15.9	----	1.1
S. Concord	1974	8/30	B	2.5	.08	29.5	2	16.5	.66	.47
S.V. 5247	1969	8/23	B	1.9	.32	5.8	6	18.8	.92	3.5
S.V. 5276	1969	8/17	W	10.1	.42	23.7	9	16.7	----	1.2
S.V. 18-283	1969	8/23	B	2.2	.31	7.0	4	17.0	.87	1.8
S.V. 18-315	1969	8/23	B	19.6	.25	79.3	4	14.3	----	1.2
S.V. 23-512	1972	8/16	W	11.8	.26	44.8	5	14.9	----	2.5
V 64232	1973	9/14	B	1.8	.12	15.3	4	14.6	----	1.9
V 54282	1973	9/14	-	1.7	.14	12.0	1	15.0	----	
V 65164	1973	8/30	R*	.32	.07	4.3	6	17.3	----	2.2
VPI 26	1969	8/17	R	29.6	.29	102.6	8	13.4	.21	4.3
VPI 30	1969	8/17	B	16.1	.24	68.3	4	17.6	----	2.9
VPI 31	1973	8/30	B	.2	.05	4.0	1	14.5	----	.75

THE CHEMISTRY OF WINE FLAVOR

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"Wine", according to Professor Maynard Amerine, "is a chemical symphony composed of ethyl alcohol, several other alcohols, sugars, other carbohydrates, polyphenols, aldehydes, ketones, enzymes, pigments, at least half a dozen vitamins, 15 to 20 minerals, more than 22 organic acids and other grace notes that have been identified" (1). In a liquid so complex, it is obvious that even minor changes in the balance of these components can profoundly affect the characteristics of the wine. Professor Amerine goes on to observe that "the number of permutations and combinations of these ingredients is enormous and so, of course, are the varieties and qualities of wine" (1).

It is my purpose in this paper to show that the bewildering multiplicity of compounds that affect our appreciation of the marvelous beverage may be understood in terms of deriving from a few simple sources. The flavoring components of wine come, in fact, from three prinicpal sources:

1. The grape from which it is made
2. The fermentation process
3. The aging process

The fate of wine is, ultimately, to be enjoyed and the final enjoyment of wine derives from tasting it. The taste of the wine itself arises from a combination of two senses--those of taste and smell--with the sense of touch or mouthfeel modifying the total impact of these and, hence, our total appreciation.

The sense of taste may be divided into four principal or basic tastes:

1. Sourness
2. Sweetness
3. Bitterness
4. Saltiness

All these tastes, with the exception of saltiness, are to be found in wine, and even this last may be present in wines from specific areas. An example of this is Manzanilla sherry, the grapes for which are grown close to the Atlantic Ocean and are thus coated with the salty spray blown inland from the surf by the prevailing westerly winds.

The perceptors for these tastes are to be found on different regions of the tongue.

Figure 1
Location of Taste Receptors on the Human Tongue

Bitter

Sour

Salt
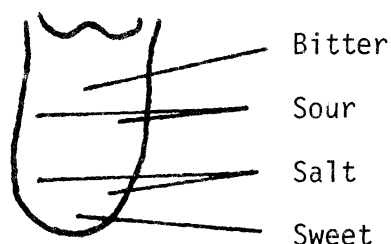
Sweet

Sweetness is to be found at or near the tip; sourness is determined at the sides towards the back; while bitterness is most readily perceived at the extreme back of the tongue. It follows, therefore, that the taster, to get the full impact of the wine, should undertake to coat the whole tongue and mouth with the wine being tasted. It should not be inferred that the taste receptors are located only at these points on the tongue. It is at these points where they are most concentrated and, thus, where the sensation is most readily perceived. The receptors are to be found over the whole surface of the tongue.

In wines, sourness is caused by acids; sweetness by sugars and, to some extent, alcohol; and bitterness by the tannins and other polyphenols. Bitterness is often confused with astringency which is more of a tactile or mouthfeel characteristic.

The other components of taste come really from olfaction or the smell of the wine. The olfactory organ is located in the nose which helps to explain why a person with a heavy head cold can often not "taste" the food being eaten. The sense of smell is more sensitive than the sense of taste as the following table shows.

Table 1
Sensitivity Thresholds for Different Compounds

Compounds	Threshold (ppm)
Tastes:	
Sugar (sweet)	6000
Sodium Chloride (salt)	1100
Hydrochloric acid (acid)	21
Quinine sulfate (bitter)	3.89
Odors:	
Butanol	0.500
Benzaldehyde	0.350
Linalool	0.006
Dimethyl sulfide	0.00033
Hex-3-enal	0.00025

(Data taken from 5 and 6

Of course, if we were animals that relied on our sense of smell, the odor thresholds would be much higher. Beagles are approximately one thousand times as sensitive to smells as humans. The question arises as to whether Snoopy and his cohorts could be used in a taste panel!

Attempts to classify scents in the same way as tastes have been divided into four basic components and color into three have been largely unsuccessful. Some people have hypothesized as few as seven primary odors--camphoraceous, pungent, ethereal, floral, pepperminty, musky and putrid (4). However, current opinion seems to favor about 32 primary odors (3).

The predominant flavors in the grape are organic acids and volatile alcohols. In fact, about 15 of the latter have been identified (9). These arise mainly from the natural metabolism of the tissue. Eighteen organic acids have been found which also arise as the result of metabolism. The most important of these are malic and tartaric acids. There is no doubt that, although the taste of wine is the resultant of all the components present--acidity, sweetness and tannin--the acidity is by

far the most important feature as may be shown by even a cursory glance at the tasting terms used to describe wine. The majority of these pertain to different degrees of acidity and one can cite such terms as flat, fresh, balanced, hard, tart, sour, green, pricked, piquant, etc.

Many of the acids and alcohols contribute to the characteristic aroma and flavor of the grape. Linalool, for example, is characteristic of Muscat grape varieties and has also been found in Johannisberg Riesling grapes which lends credence that Johannisberg Riesling has some Muscat in its parentage (8,9). Methyl anthranilate is the compound that gives labrusca grapes their typical flavor.

Other factors contributing to the taste of grapes are the tannins which are astringent but which are found mainly in the seeds and skins.

Many of the fruity grape flavors are lost during fermentation by entrainment with the escaping gas. In wine, however, the process of fermentation adds new flavors to the already complex brew. Normal yeast metabolism of the fatty acids and amino acids, for example, gives rise to the higher alcohols, also known as the fusel oils (2) as shown in Table II. In addition, there are some 24 other volatile acids (including acetic acid), 17 other alcohols, 20 carbonyls and acetals and 55 esters (9). Furthermore, the normal fermentation process produces small quantities of glycerin (glycerol) which contributes to both flavor and mouthfeel. Small amounts of acetaldehyde and trace amounts of other aldehydes are produced and can be further oxidized to acids. Small amounts of acetic acid, the acid found in vinegar, are produced by this method even in a normal, clean fermentation. The major component produced in fermentation, however, is ethyl alcohol. The disappearance of the sugar and the extraction of tannins further changes the flavor of the liquid.

Finally, small amounts of sulfur dioxide are added to the must. In itself, this has a characteristic pungent aroma and can be changed during fermentation and aging to hydrogen sulfide, the predominant odor note in rotten eggs. This, I hasten to add, takes place only under very adverse conditions.

Table II
Sources of Some Volatile Alcohols in Wine

Alcohol	Source
n-Propyl alcohol	Threonine
n-Butyl alcohol	Threonine
Isobutyl alcohol	Valine
n-Amyl alcohol	Threonine
Isoamyl alcohol	Leucine
Active amyl alcohol	Isoleucine

More changes occur during the aging of wine. If aged in wood, further extraction of tannins takes place. However, one of the predominant features of aging is the disappearance of acids and tannins. The acids may be lost through precipitation as potassium bitartrate or by the conversion of malic acid to lactic acid in the malo-lactic fermentation. The tannins, during aging, tend to polmerize and precipitate out leaving the wine smoother as a result. Oxidation seems to play an important part in this process.

Oxidation is, in fact, possibly the most important chemical change occurring during the aging of wine. It is at the same time a blessing and a curse. It pro-

duces the rounded, honey-like quality in a wine known as "bottle-age". If carried too far, however, it causes the flat smell and taste and the brown color of a typical maderized wine. The principal feature of this reaction is the conversion of the ethyl alcohol to acetaldehyde, although more complete changes also occur. This reaction is deliberately induced in sherry wines either by allowing the wine to oxidize slowly in partially filled barrels or by heating the wine and bubbling air through it. Due to the flor yeast common in the first method, a finer and more subtle flavor is produced. These strong oxidized flavors tend to overwhelm many of the other vinous flavors which explains why good sherries can be made from labrusca grapes and are enjoyed even by people to whom the typical "foxy" labrusca flavor is nothing short of anathema.

During the aging process, the characteristic fruity flavor of the young wine tends to disappear and is replaced by a more complex taste. In wine tasting, we differentiate between these two sources of odor in a wine by referring to those scents derived from the grapes used as the aroma and those due to fermentation and aging as the bouquet.

Many of the volatile compounds in the grape are probably lost in the aging process by oxidation. However, there is a third mechanism which occurs during aging whereby the organic acids and the alcohols react together to form esters. This process of esterification is most important in wines and research has shown that some fifty percent of the volatile components in a young wine are esters compared with about five percent in the grape (7,8). Since esters have quite different smells from their parent compounds, this transformation is most important.

To sum up, then, the flavor of wine is a composite of taste and smell with mouthfeel playing a significant part. Taste originates with acidity, sweetness and tannin and is much affected by the balance between these three parameters. The smell of the wine derives from the volatile compounds is affected by the grape variety, the fermentation process and the aging process. All of these affect, to some degree or other, the balance among the 200 or so components which contribute to the overall smell of the wine.

Since I began this talk by quoting from Professor Amerine, let me close by once more quoting from him. "Considering the complexity of the subject," he observes, "it is not surprising that perhaps more nonsense has been written about the making, uses and appreciation of wine than about any other product of man or nature."(1)

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CHANGES IN THE CHEMICAL COMPOSITION DURING WINE FERMENTATION

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The composition of the musts provides a source of nutrients for the growth of the yeasts to produce a wine. During the fermentation, these components are modified, and the final product is the end result of the yeast metabolism. Following fermentation, we also have changes taking place because the physical property of the medium has changed, we have physical-chemical changes taking place during the "aging" process. This discussion will be concerned primarily with the changes taking place in the musts during the fermentation. In order to organize this discussion in some logical progression, we will discuss the changes occurring according to the chemical grouping of the components of the musts.

Carbohydrates

The major chemical component of the must, next to water, is the carbohydrate fraction or sugar. These sugars comprise between 1/4 to 1/5 of the must. The primary sugars are the hexoses, glucoses, fructoses, and the disaccharide, sucrose. Other sugars, such as the pentoses or abinose, and ribose and the disaccharide, maltose, are present in lesser concentrations (10). The degradation of the sugar to alcohol by the yeast is the primary product of fermentation. This degradation is the result of a series of biochemical reactions.

Figure 1 is an abbreviated form of the biochemical reactions of the alcoholic fermentation. The predominant reaction leads to the formation of ethanol. However, one can see that the formation of other components, which are present in the wine, will be formed during the production of ethanol. A few of these compounds are glycerol, acetaldehyde, and lactate. We will discuss the effect of the TCA cycle later in this discussion.

Glycerol is second to ethanol as the major product of the fermentation in wines. The concentration according to Amerine (1) usually varies between 0.5 and 1.5 g/100 ml of wine. A survey of the glycerol content in New York State wines was conducted in 1970 (11) and the limits observed were 0.26-1.47 g/100 ml, with an average of 0.83 g/100 ml. The white wines were lower than the red wines. This was probably due to the fact that the white wines were fermented at a lower temperature than the red. Most enologists consider that glycerol is of considerable importance because of its sweet taste and oily character. However, the threshold data (2,5,6) does not indicate that glycerol is of importance in the quality of a wine, and certainly not a sweet wine. On the other hand, Amerine (1) stated that glycerol had a measurable influence on taste, and is sometime used in the enological ratio to detect sophistication. Hickinbotham and Ryan (4) probably came up with the best explanation that glycerol imparted smoothness to the wine and ameliorated the burning taste of the alcohol.

The relationship of the yeast cell count, ethanol concentration, and glycerol concentration during fermentation is shown in Figure 2. One can see that the glycerol and the cell count are correlated, while the ethanol lags behind the cell count. It can be easily seen that the glycerol concentration reaches maximum when the cell count reaches maximum and that the ethanol is primarily produced after the cell count has reached its maximum (12). This would be due to the formation in the metabolic scheme (Fig. 1) of the three glycerol phosphate and without the presence

Figure 1.
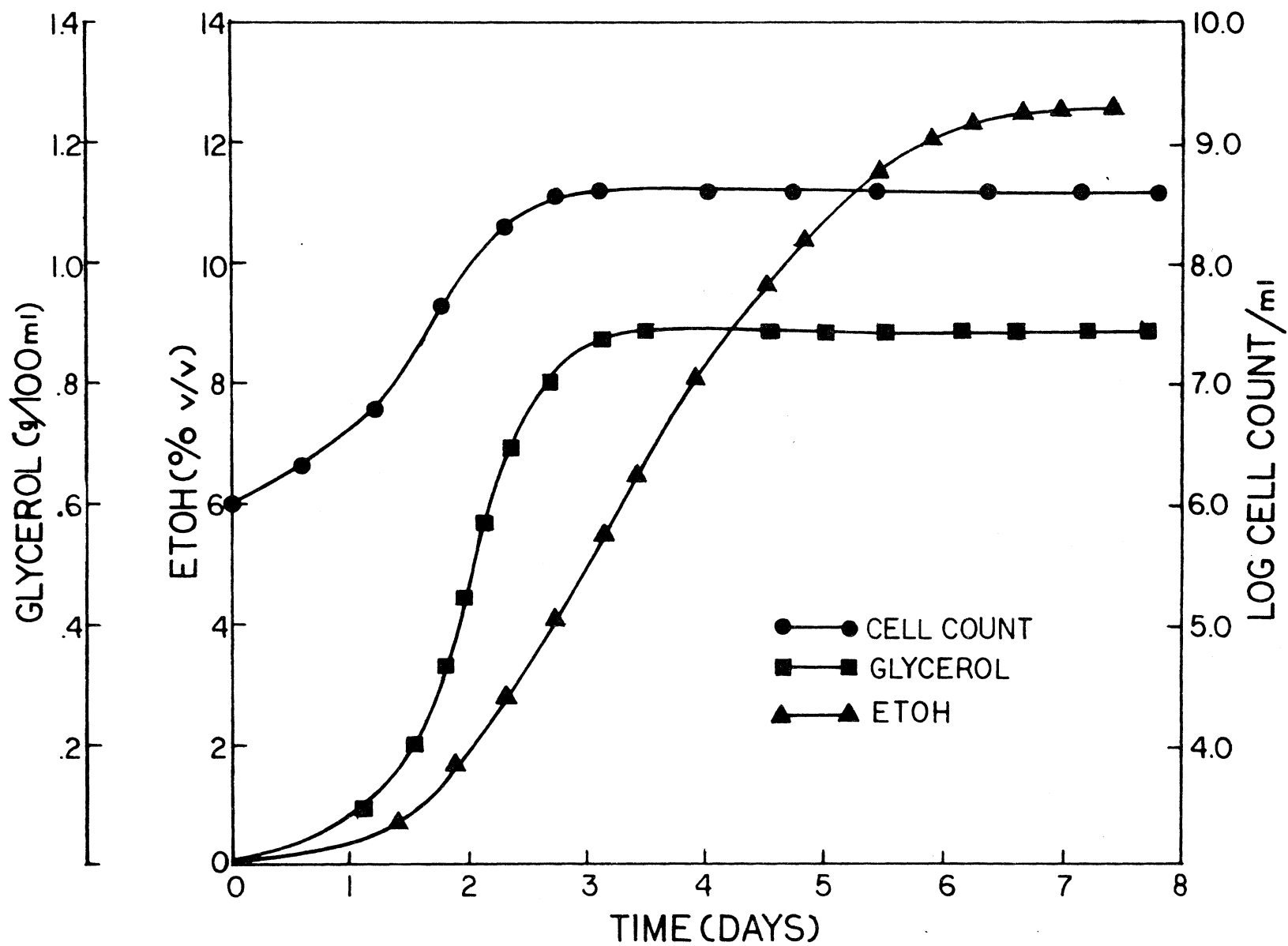
The Emden – Meyerhof – Parnas Glycolysis Sequence
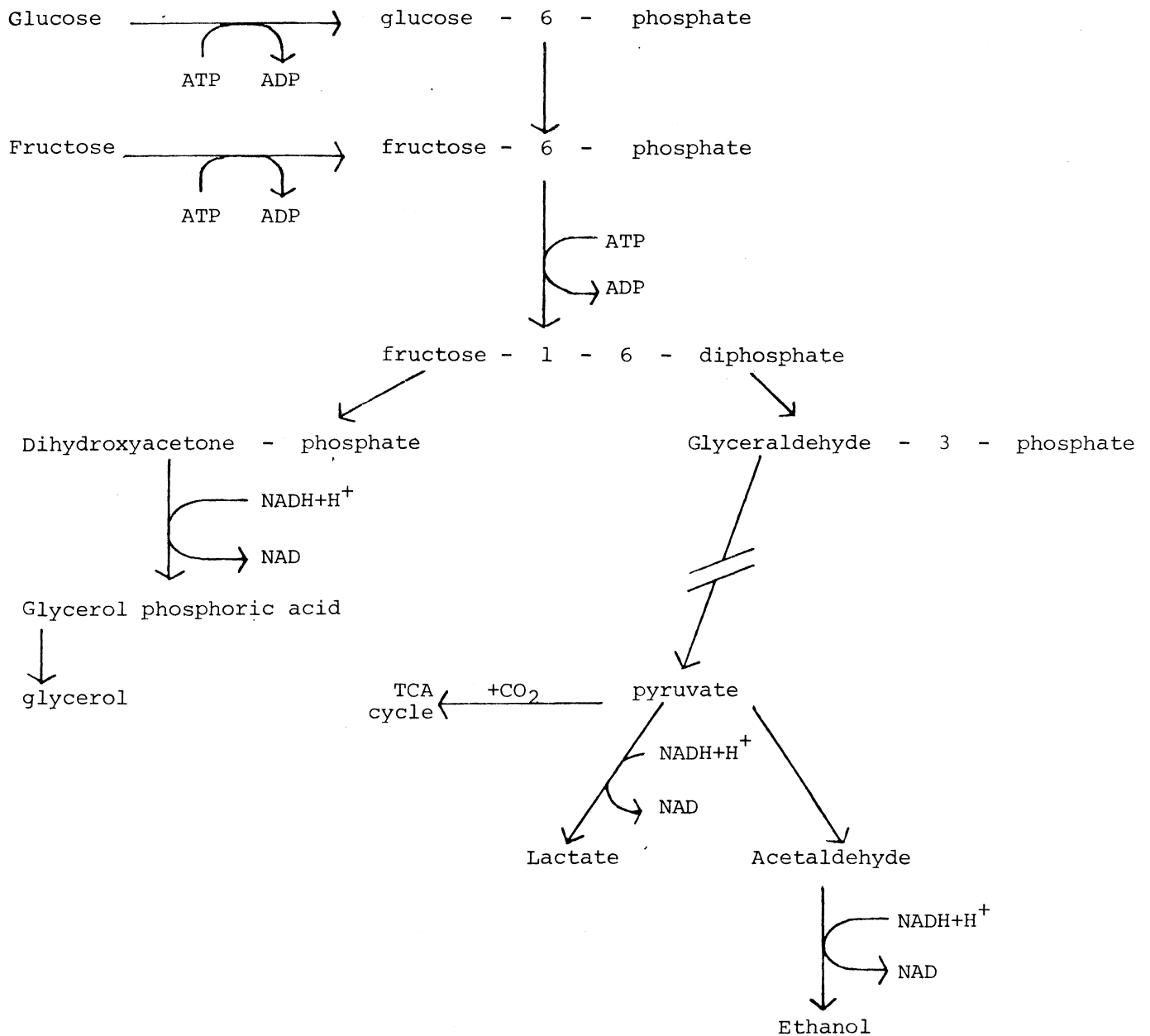
Figure 2. Relationship of yeast cell count to Ethyl alcohol and glycerol during fermentation.

of acetone, dihydroxy acetone phosphate would act as a hydrogen acceptor and glycerol would be formed. When in the later stages the pyruvate is formed and decarboxylated to acetaldehyde the acetaldehyde accumulates and serves as the hydrogen acceptor in place of the dihydroxy acetone phosphate and little, if any, glycerol is formed. If the acetaldehyde is removed, such as binding with sulfite, the initial phase continues and more glycerol is produced. Acetaldehyde is usually found in the wines below 75 parts/million, at the end of the fermentation. At this concentration, it has little sensory importance, especially since sulfite is usually added to the wine. Although it does have a pronounced odor (Berg, et al. (2) reported a threshold of 1.5 parts/million in water), Hinreimer, et al. (5,6) found different thresholds when in wine, 100 to 125 parts/million.

Acids

The grape must contains two major acids, malic and tartaric, and a minor acid, phosphoric. Phosphoric acid accumulates in the grape during its maturation ending with a final concentration of approximately 0.02-0.04% (9). This acid disappears from the must within three days after the initiation of fermentation (7). As can be seen in the Emden-Meyerhof-Parna glycolytic sequence, phosphate is required to convert a sugar to alcohol. The phosphate is used by the enzymatic system of the cell and following fermentation, the phosphate will again reappear at approximately 1/4 to 1/2 of the original concentration. The reappearance occurs at the same time the cells begin to autolyze.

The tartaric and malic acids of the musts are found in the resulting wines. These two acids account for approximately 80% of the organic acids in a must. They are important constituents of the wines not only for their acid tastes, but also they protect the wine from spoilage and maintain the color. During the course of the fermentation, the concentration of these acids decrease. Malic acid disappears during the alcoholic fermentation to the extent of 10 to 30%. This may be due to the splitting off of two hydrogen atoms and decarboxylation of the resulting oxal-acetic to acetaldehyde, which in turn acts as an hydrogen acceptor and is reduced to alcohol. Figure 3 shows this reaction from malic acid to acetaldehyde. A decrease in tartrates is caused primarily by the deposition of potassium acid tartrate. Potassium acid tartrate occurs in grapes as a saturated or nearly saturated solution. Since the potassium acid tartrate is less soluble in alcoholic solutions, it precipitates during the fermentation.

Nitrogenous compounds

The nitrogen containing compounds of the must are important to the enologist for several reasons: free amino acids serve as nutrients for the yeasts in the fermentation and they are also precursors to the flavor-producing higher alcohols.

In a study on three eastern varieties, Concord, Catawba, and Delaware, the most abundant amino acids in all three varieties were glutamic acid, α-alanine, and arginine (8). It has been suggested that the large amount of alanine present in a labrusca variety compared to the vinifera may simply be due to genetic differences between the two species.

Changes in the free and total amino acids of the musts were examined during fermentation (7). With the exception of proline, lysine, and glycine, there was a dramatic reduction in the free amino acid content by the sixth day following inoculation. At the end of the fermentation there was an increase in the concentration of the free amino acids due to yeast cellular autolysis; however, the quanti-
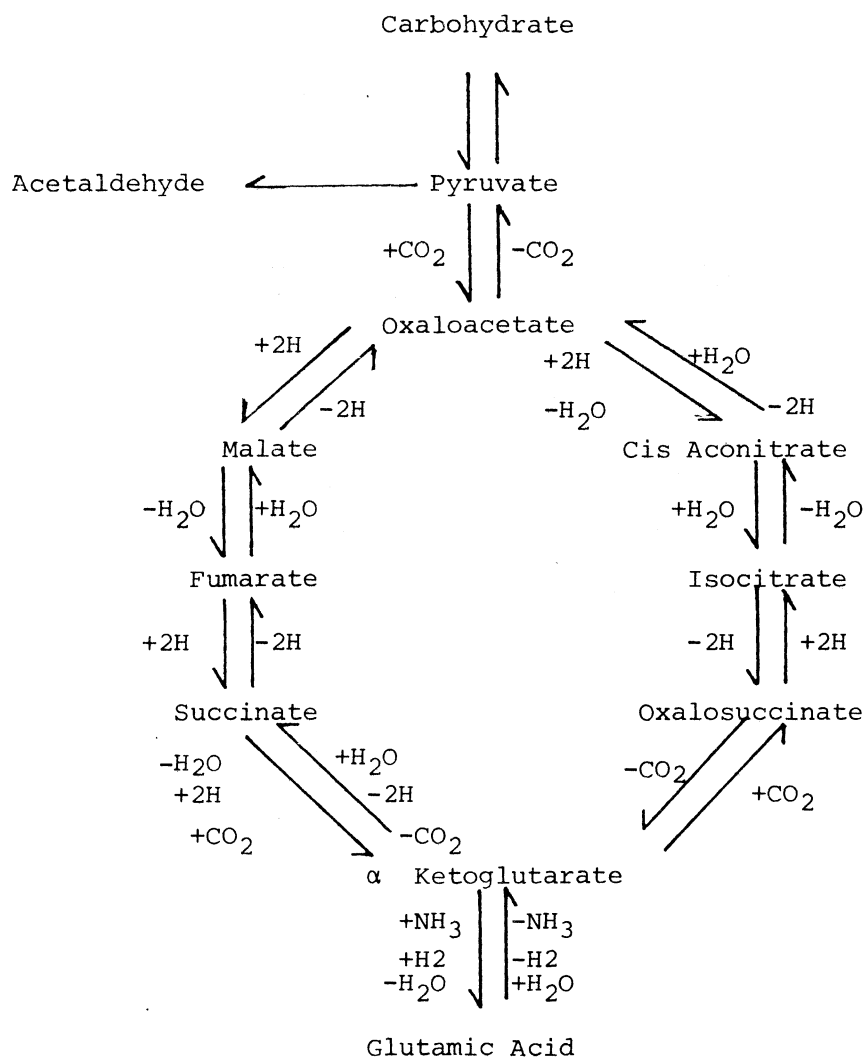
-31-

Carbohydrate

Figure 3. Tricarboxylic Acid (TCA) Cycle

ties ranged between 2 and 30% of the initial must values. Proline was apparently not utilized by the yeast during the fermentation. With the exception of proline, which averaged 16.4 mg/100 ml wine, all the free amino acids were present in amounts less than 3 mg/100 ml in the final wine samples. Small amounts of β-alanine, ornithine, and citrulline were found, and cystathionine was detected at the end of the fermentations. Total amino acid concentrations determined from the hydrolyzed wine samples showed similar trends to the free amino acids during fermentation. Next to proline, the most abundant of the total amino acids, were glutamic acid, aspartic acid, lysine and glycine. In contrast to proline, which existed mostly in the free form, these four amino acids were found to be present primarily in the protein and polypeptide form. Levels of protein and total nitrogen decreased initially then increased during the later stages of the fermentation. An average of 26.1% of the total nitrogen in the wine at the end of the fermentation was due to free amino acid nitrogen. Ammonia apparently readily utilized by the yeast, decreased rapidly during the fermentation.

As previously mentioned, amino acids give rise to higher alcohols or fusel oils.

The production of fusel oils from amino acids is shown in Figure 4. If the amino acid in this figure was leucine, then the corresponding alcohol produced would be isoamyl alcohol; isoleucine-active amyl alcohol; valine-isobutanol; and phenylalanine-phenyl ethyl alcohol.

Castor and Guymon (3) found that the fermentation of the fusel oils paralleled the formation of ethyl alcohol. Guymon and Heitz, as well as others, found that red wines contain slightly more higher alcohols than the white wines. These authors noted the sensory importance of higher alcohols in wines; very low concentrations play a desirable role in the sensory quality. It has been noted that a considerable difference exists in the capability of yeast to produce higher alcohols. The amounts in table wines vary from 0.14 to 0.42% in dessert from 0.16 to 0.90%.

During the fermentation of the wine, succinic acid is formed. The concentration will vary in the finished product between 0.03 to 0.07%. Succinic acid will be produced during the initial phase of the fermentation. The precursor of this acid is the amino acid, glutamic acid. Figure 3 shows the pathway of its development from glutamic acid to ketoglutaric acid by deamination and then to succinic acid by decarboxylation.

Summary

During the course of fermentation reducing sugars decreased as ethanol concentration increased; total acidity, pH, tartrates, malates, and phosphoric acid decreased; and succinic acid increased.

The amounts of both free and total amino acids decreased dramatically after approximately a week following inoculation with the yeast, then increased slowly during the latter part of the sampling period to levels between 2 and 30% of the initial must concentration. These increases were due primarily to the yeast cell autolysis. The most abundant of the free amino acids in the must was α-alanine while proline was the major acid following fermentation. Proline was not reduced during the fermentation. In the total amino acid analysis, proline, glutamic acid, aspartic acid, lysine, and glycine were found in greatest quantities. Ammonia decreased during the fermentation while the protein and polypeptide content decreased then slowly increased to about 50 mg/100 ml of wine in each variety. The presence of high levels of protein and polypeptide material may have an important influence

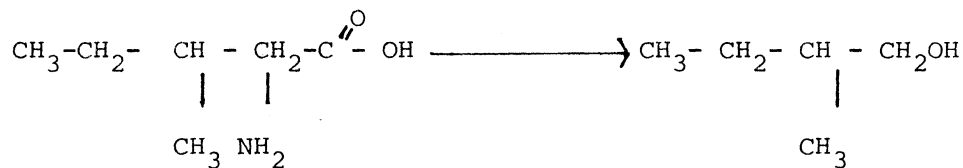.Figure 4.

Formation of Higher Alcohols from Amino Acids

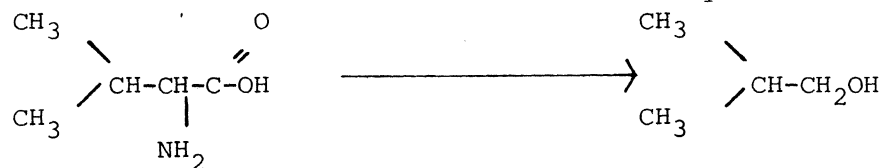leucine   Isoamyl alcohol
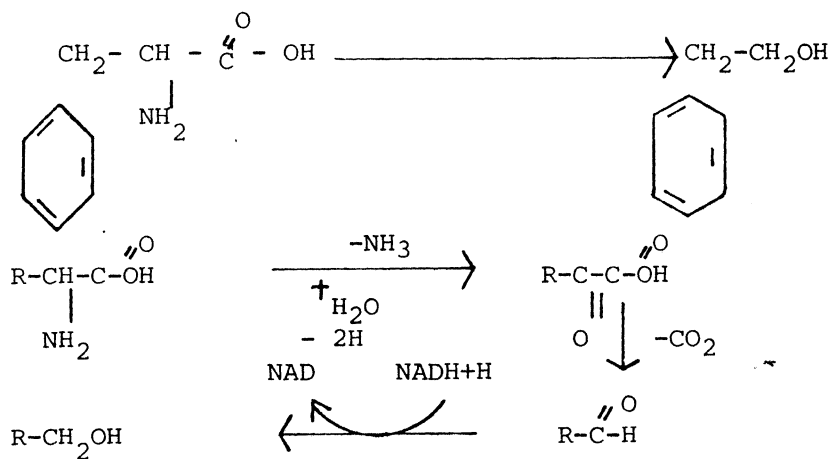
$$CH_3 \diagdown CH - CH_2-CH-C\overset{O}{\diagup}-OH \longrightarrow CH_3 \diagdown CH-CH_2-CH_2OH$$
$$CH_3 \diagup \qquad\qquad\quad | \qquad\qquad\qquad CH_3 \diagup$$
$$NH_2$$

Isoleucine   Active Amyl Alcohol

$$CH_3-CH_2- \quad CH - CH_2-C\overset{O}{\diagup}- OH \longrightarrow CH_3- CH_2- CH - CH_2OH$$
$$| \qquad | \qquad\qquad\qquad\qquad\qquad |$$
$$CH_3 \quad NH_2 \qquad\qquad\qquad\qquad\qquad CH_3$$

Serine   Isobutyl Alcohol

$$CH_3 \diagdown \qquad\qquad O \qquad\qquad\qquad CH_3 \diagdown$$
$$CH-CH-C-OH \longrightarrow CH_3 \diagup CH-CH_2OH$$
$$CH_3 \diagup \quad | \qquad\qquad\qquad\qquad CH_3$$
$$NH_2$$

phenylalanine·   phenyl ethyl alcohol

$$CH_2- CH - \overset{O}{C} - OH \longrightarrow CH_2-CH_2OH$$
$$| \qquad\qquad\qquad\qquad\qquad\qquad\qquad$$
$$NH_2$$

$$R-CH-C\overset{O}{\diagup}-OH \xrightarrow[\substack{+ H_2O \\ - 2H \\ NAD \quad NADH+H}]{-NH_3} R-C-C\overset{O}{\diagup}-OH$$
$$| \qquad\qquad\qquad\qquad\qquad\qquad || \quad \downarrow -CO_2$$
$$NH_2 \qquad\qquad\qquad\qquad\qquad O$$

$$R-CH_2OH \longleftarrow \qquad\qquad\qquad R-C\overset{O}{\diagup}-H$$

on the nutrition of the malo-lactic organisms as a secondary fermentation and affect the protein stability of the finished wine. Further, during fermentation from the free amino acids we have the fusel oils produced.

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JAPANESE BEETLES: CONTROL AND RESEARCH

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The Japanese beetle is one of the best known insect pests ever introduced in-
to the United States from outside its shores. First found in a commercial nursery
in Riverton, New Jersey, in 1916, the pest is believed to have been introduced into
this country with a shipment of Japanese Iris before passage of the Plant Pest Act
of 1912. This was the pioneer act which first established regulations governing
the importation of agricultural commodities brought into the United States from a-
broad. From the first few shining beetles discovered feeding on ornamental plants
in that nursery during mid-August over sixty years ago, this pest, despite strenuous
early efforts at eradication, has extended its range until it now infests over two-
hundred thousand square miles in the Southern, Eastern, and Midwestern states. In
addition to coping with an ever-increasing area of infestation, each year elaborate
precautions also must be made to prevent the spread of the pest by jet aircraft and
other vehicles into areas as yet uninfested. Hitchhiking beetles have been inter-
cepted in Europe, the Azores, and in several western states including California
which has already eradicated 2 infestations and where last year beetles were inter-
cepted at 4 major airports.

The annual life cycle of the Japanese beetle is a fairly simple one. Eggs
laid by the adults during July and August soon hatch into tiny grubs that develop
progressively into larger grubs that during October move deep in the soil to over-
winter. In the spring they complete feeding and they turn into pupae during May or
June. A new generation of beetles emerges from the ground in July and August to
continue the cycle. The larvae, though of little consequence to viticulture, are
major pests in their own right and do serious damage to lawns, pastures, corn, and
a number of nursery and ornamental plants. Populations in turf of 40-80 grubs per
square foot (1.5-3 million per acre) are not uncommon.

The adult beetles are voracious feeders attacking the fruits, foliage, or
flowers of close to 300 species of fruits, vegetables, and ornamental plants. In
Japan, the beetles, though nowhere nearly as numerous as in the United States, at-
tack Vitis vinifera varieties of grapes and Vitis thunbergi. In our country, they
feed heavily on many varieties and hybrids of V. vinifera parentage, and also at-
tack those of backgrounds of new world origin, including V. labrusca, V. aestivalis,
and V. rotundifolia (the Scuppernong or Muscadine grape). On thin-leaved varieties,
beetles characteristically feed on tissue between the small veins leaving the leaves
partly or totally skeletonized often resembling fragile lace. On thick-skinned,
leathery-leaved varieties (including some with Labrusca parentage, such as Concord),
the beetles will often feed on the upper surface of a leaf, leaving a scarred, brown
surface that has lost most of its photosynthetic function. Beetles are not usually
a problem on ripening grapes, since the fruit of most varieties ripen too late to
be attacked. Thus, beetles do direct damage by removing photosynthetic tissue with
subsequent effects on overall yields, sugar content, fruit size, and plant growth.
Exactly what happens as a result of such feeding, how it happens, or how much tissue
has to be removed to bring about reductions in yields has not yet been determined.

Although Japanese beetles may appear in some vineyards almost every year, they
are not likely to be a problem at all times. Japanese beetles are gregarious feeders
and they tend to congregate on favored host plants. In most cases, it is the pro-

duction of volatile components by such plants that leads to their being attacked by the pest. Roses, for instance, produce geraniol, a substance commonly used in soaps and perfume, which is highly attractive to beetles. In grapes, one of the substances attractive to Japanese beetles is called phenethyl butyrate. A synthetic relative of this material, phenethyl propionate, was developed by our laboratory as a component of a highly effective lure for the pest. If favored varieties of grapes are within their sensory range, the insects inevitably seem to locate them. The numbers of beetles attacking a vineyard, however, will depend upon the location of breeding sites (grassy areas, such as lawns, pastures, golf courses) within flying distance of the pests. Beetles can fly several miles, consequently, vineyards near to large areas of infested turf often suffer severe damage following heavy emergence of beetles in early summer. Furthermore, since the pests may live from 30 to 60 days, severe defoliation may also occur as a result of continual feeding by fewer numbers.

Since evidence for predicting losses from feeding damage does not exist, a decision to apply pesticides or not is still largely dependent upon grower judgment. Pesticides currently registered for control of beetles include malathion, carbaryl, methoxychlor, and parathion. The last of these is highly toxic to humans and all pesticides, of course, must be applied according to instructions on the label. Although it is not often economically feasible for vineyard operators to prevent adult damage by controlling grubs, the numbers of beetles emerging from ungrazed turf adjacent to vineyards can be reduced by killing the grubs with pesticides or milky spore disease. The least inexpensive and most effective pesticide for the control of grubs, chlordane, has now been banned by the EPA. Materials currently available for grub control, diazinon, trichlorfon, chlorphyrifos, and fensulfothion (Ohio and Pennsylvania only), can do a good job for about a year if they are applied according to label directions. Since such pesticides may have to be applied annually, the cost of using them will probably prevent their use in any but the most severe situations.

In addition to conducting research into the development of new pesticides for the control of both larvae and adults, our laboratory has been investigating the use of a number of non-pesticidal approaches to control that may offer some promise for control applications either alone or in programs of integrated control. Among these approaches has been the development of chemical lures, or food attractants, and the female sex attractant, or pheromone, for use in traps for survey and detection of the pest. The female sex attractant, recently identified and synthesized by cooperators at the USDA Insect Attractants Laboratory in Gainesville, Florida, is a chemical substance produced by the female that is extremely attractive to males. When this material is exposed with chemical lures, however, it attracts both sexes of beetles in extremely large numbers. There is still much work to do with these materials in order to determine how they best might be used. Some scientists have suggested that by permeating the air over large areas with a female sex pheromone, the male insects will become so confused that they would not be able to find females with which to mate. Pesticides might also be combined with the attractant combination to lure both sexes of beetles away from host plants to their death.

In addition to our work with attractants, we are examining still other methods of controlling the beetle. Juvenile hormones are naturally occurring chemicals found in larval insects that keep them in an immature stage. In nature, as the insects approach the end of their larval lives, the juvenile hormones disappear and the insects then turn into adults. We have been testing some man-made versions of juvenile hormones and have found that by applying them to pupae, the intermediate state between larva and adult, monsters are formed, part pupae and part adult, that are so

deformed they can neither fly or mate. Hence, death shortly follows. Although we have shown that these substances work well in the laboratory, we have not yet achieved a large degree of success in using them in the field.

In yet another area of new research, we are examining insect-resistant plants from various parts of the world to find natural compounds that may act as deterrents to feeding. A number of such compounds and extracts provided to us by USDA chemists in Beltsville, Maryland, have already been tested, and one substance from an Indian tree called Neem, has shown remarkable activity against Japanese beetle on certain plants. This extract was tested on grapes this past summer, and although the tests were inconclusive, it did not seem that the protection provided to grapes was sufficient to prevent serious damage.

Right now, chemical controls for the Japanese beetle seem adequate for most situations. It is possible, however, that carbaryl, the most effective adulticide we have might be lost to our use as a reasult of action by the EPA. Furthermore, Japanese beetles have already developed resistance to several pesticides, specifically the organochlorines, and it is possible that they could develop resistance to those being used today.

We are conducting an active program to identify and develop new pesticides for the control of both larvae and adults. We are trying to find better materials than those we have and are particularly concerned with finding a replacement for carbaryl whose use might be suspended by the EPA. This research is a slow and lengthy process since the EPA regulations for new pesticide registrations are complex and costly, and most companies are unwilling to invest large sums of money to obtain registrations for materials merely for the control of minor pests like the Japanese beetle. They must first be assured of a market for their compounds against important pests of a major crop such as corn, cotton, or soybeans in order to meet their development costs. Only then will they consider extending development to minor pests.

NEW IDEAS IN DISEASE CONTROL--BITTER ROT AND BLACK ROT IN OHIO

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Two grape diseases, black rot and bitter rot, can be easily confused, but differences in disease control measures make it essential for growers to correctly identify these diseases. Black rot and bitter rot are of American origin, and both often occur in the same region. Bitter rot is more frequent in the South and neither disease is a problem in California.

Black rot, caused by the fungus <u>Guignardia bidwellii</u>, infects all young green tissue, causing a leaf spot as well as fruit rot. Black rot infection on the berry begins as a bleached, sunken spot that enlarges rapidly, resulting in a black mummy covered with small, dark spore-containing bodies (pycnidia).

In contrast, bitter rot, caused by the fungus <u>Melanconium fuligineum</u>, is a weak parasite and infects only mature, dying, or wounded tissue. Bitter rot is most conspicuous on berries but also infects shoots, cluster stems, and berry stems, appearing on these tissues as a black spot which enlarges and becomes covered with sooty black pustules (acervuli). The fungus may spread throughout the cluster stem before the berries ripen, resulting in poorly nourished berries that will shrivel and fall. Berries infected with bitter rot become dull brown but temporarily remain plump. Small, dark, spore-containing pustules soon appear. These are more irregular than the black rot pustules and will rupture the cuticle. Berries usually collapse and resemble black rot mummies. Bitter rot-infected berries often taste bitter. Bitter rot may continue to spread in fruit after harvest.

Black and bitter rots are spread by splashing rain, and water is necessary for infection. Visual symptoms of both diseases usually appear about one week after infection.

A key difference between black rot and bitter rot involves the relationship between berry maturity and susceptibility to infection. As berries begin to color, they become resistant to black rot. Bitter rot, however, is a rot of ripe grapes and does not appear until the fruit is about full size and beginning to ripen. As a result, bitter rot can be a significant problem where berries are left too long on the vine in hopes of getting increased sugar content.

Control of black rot and bitter rot is similar in many respects but drastically different in others. In vineyards practicing cultivation for weed control, burying black rot and bitter rot mummies will reduce the number of spores available for infection the following season. In addition, because both diseases are favored by warm, wet weather, practices such as weed control and row orientation to low humidity and hasten drying will also help reduce severity.

Because black rot infects young leaves and berries, early season fungicide sprays are extremely important. Many growers begin spraying after young leaves are infected but spores are produced on these diseased leaves that later infect young berries and make disease control more difficult. For a more complete description of black rot symptoms, infection periods, and control, see the following publications: Ohio Grape-Wine Short Course Proceedings for 1974 and 1977, and Ohio Commercial Fruit Spray Guide.

In contrast to black rot, bitter rot affects only berries that are beginning to mature. Unfortunately, during this late part of the season, many growers may terminate fungicide applications. If preharvest weather becomes warm and wet, additional spraying is necessary to control bitter rot. Generally, fungicides used for black rot also control bitter rot. Read the fungicide label carefully for information on number of days allowed from last spray to harvest. For additional details concerning bitter rot, see Eastern Grape Grower, October 1977 issue, article by Dr. John McGrew.

COLD HARDINESS OF VINIFERA HYBRIDS

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Dormant hardwood cuttings of most cultivars were supplied by cooperators at the Agricultural Experiment Stations in California, New York and Ohio. The cuttings were callused and rooted in the greenhouse at the Illinois Horticultural Experiment Station during the 1974-75 winter and planted in the vineyard in the Spring, 1975. The single curtain and Munson trellises were erected before planting to provide support for the growth from the 2 rooted cuttings of each cultivar. Intensive training during the growing season enabled establishment of the vine framework in the first year for many cultivars. The vineyard was established on Hosmer silt loam soil and clean cultivated with a winter wheat winter cover crop. The vines were not irrigated, and a minimal spray schedule was applied with an air blast sprayer. Ten-pound fruit samples were harvested for wine making from a number of cultivars during the second growing season after planting.

Winter Weather, 1975-76

A long preconditioning period for cold tolerance occurred before the critical low temperature on January 9, 1976. Starting December 15, 1975, the air temperatures were continuously below 45°F until January 11, 1976, except for a 50°F maximum temperature on January 3. The January mean temperature was 31.9°F, lower than the normal 34.3°F. The lowest official temperature of the 1975-76 winter was -4°F on January 9. The Grass Temperature (GT) recorded by an unsheltered minimum-registering thermometer, located 1 foot above grade in the vineyard, was -8°F. Thermograph charts indicated that air temperatures remained below 0°F for 8 hours. On January 13, the daily maximum temperature was 62°F. The soil was wet with a very thin snow cover on January 9. Soil temperatures recorded were: 31°F at the 2-inch depth, 22°F at the 6-inch depth and 35°F at the 18-inch depth. The roots of these young vines were probably concentrated between the 6- and 18-inch depths and exposed to 22°F for a prolonged period.

Cold Hardiness, 1975-76

Most vines of Vinifera cultivars were killed to the ground by the minimum temperature -4°F (GT-8°F) on January 9 when possible protection from snow was absent (Table 1). Many of the vines were retrained from root suckers which emerged in the spring. A few Vinifera cultivars were not damaged: French Columbard, Royalty, Rubired and Ruby Cabernet. Single vines of the following cultivars survived in good condition: Aligote, Chenin Blanc, Pinot Chardonnay, Prune de Cazouls, Tinte Madiera, Veltliner and Zinfandel. Both vines of the following cultivars were completely killed: Ohanez, Scarlet, Sultana, Tokay and Tokay Seedless.

Clark (4) found a few live buds on all of his Vinifera cultivars, except Italia and Tokay, after a minimum temperature of -4°F in 1936. Although, 100% of the dormant buds on Vinifera cultivars were killed by -16°F in 1934 and -14°F in 1935, trunk and root killing was not reported.

Most hybrid cultivars with a notable proportion of <u>Vitis vinifera</u> parentage (VH) adequately survived the GT -8°F on January 9, 1976 (Table 2). However, single vines of the following cultivars were killed to the ground: Canadice, Interlaken Seedless, Le Commandant, Leon Millot, Muscat St. Vallier, New York Muscat, Rougeon, Vincent, Humbert 3, NY GR 1, NY GW 5, NY GW 9, NY GW 10, NY 18135, S 7136, S 10076 and SV 18307. Both vines of these cultivars were killed to the ground: Baco Noir, Landot 4511, NY GW 8, NY 18080, S12481, and Vineland 49063.

The greatest majority of hybrid cultivars with predominant American species parentage (AH) in Table 3 were not damaged by the GT -8°F on January 9, 1976. Single vines of the following cultivars were killed to the ground: Beacon, Dearing, Kendaia, Price, Ripley, Westfield and Vineland selections 37031, 51011, 52082, 53043 and 292718. Entire vines of the following cultivars were killed: McCampbell, Moored, Scuppernong, Vincent and NY 12943.

Winter Weather, 1976-77

The preconditioning period for cold tolerance in the 1976-77 winter was about 4 days. The December 1976 mean temperature was 32.2°F, lower than the normal 36.7°F, and other temperature parameters were similarly low. Daily temperature fluctuations were a prominant feature late in December. After a 57°F maximum temperature on December 27, the temperatures stayed below 45°F for 37 days, until February 3. On December 31, the minimum temperature was -8°F (GT -12°F), and on January 1 the minimum temperature was 0°F (GT -8°F).

The January 1977 mean temperature was a record 17.1°F, about half the normal 34.3°F. New records were set by the mean minimum temperature 7°F, compared with the normal 25.0°F; and the -904 Algebraic Degree Days 50°F (ADD) compared with the normal -569.4 ADD. A series of severe freezes, totaling 124 hours below 0°F, started on January 10 and ended on February 7. The most severe freeze, an official minimum -20°F (GT -30°F) on January 17, was the second lowest temperature recorded since 1893 at Carbondale.

January precipitation was 1.52 inches melted snow, less than the normal 3.39 inches. However, a 9-inch snowfall on January 9 covered the ground until February 10. In January, grape vine roots were exposed for a considerable period to soil temperatures of 33°F at the 2-inch depth, 19°F at the 6-inch depth and 32°F at the 18-inch depth.

Cold Hardiness, 1976-77

The official minimum temperature -20°F (GT -30°F) recorded on January 17, 1977 caused several types of vine damage, ranging from no apparent damage to several degrees of dormant bud mortality on canes, blackening of inner bark (primary phloem) on the trunk, trunks killed to the snow line or the ground, or complete killing of all parts of the vines. Blackening of the inner bark on the trunk occurred on some vines with apparently undamaged bark on the canes.

The 9-inch deep snow cover apparently gave about 22°F protection from cold damage. In 1976, many Vinifera cultivars were killed to the ground by GT -8°F, and the same vines were killed only to the snow line by GT -30°F in 1977: Cardinel, Dodrelabi, Italia and Malaga in Table 1. Only suckers from the roots on these vines survived in 1976, but shoots arose from the trunk below the snow line in 1977.

The vines of Vinifera cultivars in Table 1 were commonly killed to the snow line

after GT -30°F on January 17, 1977. Veltliner was the only cultivar to survive apparently undamaged. Single vines of the following cultivars were killed outright: Black Monukka, Black Morocco, Cabernet Sauvignon, Castiza, Corinth Noir, Emerald Riesling, Grenace, Kaadahar, Perlette, Prune de Cazouls, Rubired, Ruby Cabernet and Zinfandel. Both vines of the following cultivars were killed outright: Calmeria, Mission, Muscat Alexandria and Palomino.

The VH cultivars in Table 2 which survived GT -30°F essentially undamaged (Score 1) were: DeChaunac, Leon Millot, Le Suberaux, Ravat Noir, Rosette, Totmur, Villard Noir, BS 2846, Castel 19637, Humbert 3, JS 23416, JS 26627, NY GR 7 and SV 5247. Representative cultivars sustaining degrees of dormant bud mortality (Scores 2, 3, 4,) were: Agawam, Cayuga White, Roubideaux, Rougeon, and Vignoles. Inner bark blackening on the trunk above the snow line (Score 5) was temporary on some cultivars: Alden, Aurore, Bath, Brighton, Chancellor, Golden Muscat, Marechal Foch, New York Muscat, Seyval, Sheridan and Villard Blanc. The bark blackening on other cultivars extended below the snow line and was associated with trunk killing to the snow line (Score 6), Himrod, Interlaken Seedless, Lakemont, Schuyler, Seneca and Suffolk Red. The great majority of VH cultivars were killed to the snow line. A few cultivars generated root suckers after being killed to the ground (Score 7): Cascade, Century 1, Rocaneuf, Romulus, S 12481, S 13666 and S 14117. Entire vines of a few cultivars were killed outright: Gaertner, Muscat St. Vallier, Couderc 29935, Landot 2281, Landot 4511, NY GR 1 and SV 18307.

Many AH cultivars in Table 3 commonly showed some degree of dormant bud mortality on canes following the GT -30°F minimum temperature. However, the following cultivars were not damaged in 1977: Beacon, Beta, Champanel, Concord Seedless, Diamond, Elvira, Hanover, Louisiana, Marguerite, Monticello, Moores Early, Mrs. Munson, Veeport, Vincent, Couderc 3306, NY 12025 and Solonis x Othello 1613. Blackening of the inner bark on the trunk, which later healed, occured on: Alwood, Buffalo, Captivator, Concord, Fredonia, Niagara, Ontario, Sheridan, Steuben and Worden. Trunks were killed to the snow line on: Blue Eye, Eden, McCampbell, Moonbeam, Piney, Portland, Price, Red Giant, Urbana and Virginia et al. Root suckers grew after the trunks were killed to the ground on Dutchess and Missouri Riesling. Vines of the following AH cultivars were killed outright: Dearing, Ellen Scott, Eumelan, Hunt, Moored, Scuppernong, Venture, A x RG 1, Rupestris St. George and Solonis x Riparia 1616.

After a minimum temperature of -29°F in 1959, Campbell and Hadle (3) recorded the survival of 18 FH and 15 AH cultivars which were also evaluated at Carbondale in 1977. Trunk damage was not reported specifically, nor the possibility of snow protection in 1959. Only Aurore, Beta, Concord, Fredonia, Rosette and Worden dormant buds were not 100% killed. With 100% dormant bud mortality, the following cultivars presumably died after failure to generate root suckers: Bath, Delaware, Ontario, Rocaneuf, Seyval, Steuben, and Ravat 34. Alden, Baco Noir, Buffalo and Le Suberaux were rated more hardy at Carbondale in 1977.

According to our 1977 hardiness scores the Group I cultivars of Cahoon (2), including Concord and Delaware, could be augmented with De Chaunac from Group II, Veeport and Villard Noir from Group III, Ravat Noir from Group IV and SV 5247. Aurore, Catawba and Chancellor should drop to Group II with Baco Noir, Niagara, and Seyval. Ventura and Vidal 256 should be placed in Group III with Chelois, Ontario, Vignoles, Villard Blanc and Vincent. Blue Eye, Chardonnay, Himrod, Landal and Price should join Group IV with Century 1, Colobel and Romulus. Rocaneuf should be classed with the tender cultivars in Group V.

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TABLE 1. Vine survival scores of 47 dormant _Vitis vinifera_ cultivars exposed to Grass Temperature -30°F on January 17, 1977 at Carbondale, Illinois.

1
Veltliner

6
Alicante Bouschet
Barbera
Cardinal
Chenin Blanc
Cornichon
Dodrelabi
Emperor
Italia
Malaga
Pearl of Csaba
Pinot Chardonnay
Ribier
Super Thompson

7
Aleatico (6)
Aligote
Carignane (6)
Danuge (6)
Delight
French Colombard (6)
Muscat Hamburg (6)
Olivette Blanche
Royalty (6)
Sultanina (6)
Tinte Madiera

8
Black Monukka (6)
Black Morocco (7)
Cabernet Sauvignon (7)
Calmeria
Castiza (7)
Corinth Noir (7)
Emerald Riesling (7)
Grenache (7)
Kandahar (7)
Mission
Muscat Alexandria
  (Ohanez)
Palomino
Perlette (6)
Prune de Cazouls (6)
Rubired (6)
Ruby Cabernet (7)
  (Scarlet)
  (Sultana)
  (Tokay)
  (Tokay Sdls)
Zinfandel (7)

Score

1 No Damage
2 Slight bud mortality
3 Moderate bud mortality
4 Severe bud damage
5 Trunk bark blackened and recovered
6 Water sprouts from crown
7 Suckers from roots
8 Dead vine
   (Dead vine, 1976)
( ) Score for other vine

TABLE 2. Vine survival scores of 94 dormant <u>Vitis vinifera</u> hybrid culti-
         vars exposed to Grass Temperature -30°F January 17, 1977 at
         Carbondale, Illinois

<u>1</u>
DeChaunac
Le Suberaux
Leon Millot
Ravat Noir
Rosette
Totmur
Villard Noir
Bertille-Seyve 2846
Castel 19637
Humbert 3
Johannes-Seyve 23416
Johannes-Seyve 26627
N.Y. GR-7
Seibel 13047
Seyve-Villard 5247

<u>3</u>
Agawam
Rougeon
Vignoles
N.Y. 36661
Seyve-Villard 12413
Seyve-Villard 23512

<u>4</u>
Cayuga White
Roubideaux
N.Y. GW-9
N.Y. 15302
N.Y. 18080

<u>5</u>
Aurore
Baco Noir
Bath
Brighton (2)
Golden Muscat
Marechal Foch
N.Y. Muscat
Seyval (2)
Sheridan (3)
Villard Blanc

<u>6</u>
Baco Blanc
Bellandais
Bokay
Canada Muscat
Canadice
Chambourcin
Chelois
Colobel
Florental
Glenora
Himrod
Interlaken Sdls.
Keuka
Lady Patricia
Lakemont
Landal
Le Commandant
Lindley
Rayon d' Or
Salem
Schuyler
Seneca
Suffolk Red
Valerien
Verdelet
Burdin 4672
Burdin 5201
Illinois 179-1
Johannes-Seyve 12428
N.Y. GR-3
N.Y. GR-8
N.Y. GW-4
N.Y. GW-5
N.Y. GW-8
N.Y. GW-10
N.Y. 18135
Ravat
Seibel 7136
Seibel 10076
Seibel 10868
Seyve-Villard 1-72
Seyve-villard 12303
Vidal 256
Vineland 49063

<u>7</u>
Cascade
Century 1
Rocaneuf
Romulus
Seibel 12481
Seibel 13666
Seibel 14117

<u>8</u>
Gaertner
Muscat St. Vallier
Landot 2281
Landot 4511
N.Y. GR-1
Seyve-Villard 18307

<u>Scores</u>

1 No Damage
2 Slight bud mortality
3 Moderate bud mortality
4 Severe bud mortality
5 Trunk bark blackened
   and recovered
6 Water sprouts from crown
7 Suckers from roots
8 Dead vine

TABLE 3. Vine survival scores of 83 dormant American species hybrid grape
cultivars exposed to Grass Temperature -30°F on January 17, 1977
at Carbondale, Illinois

1

Beacon
Beta
Champanel
Concord Sdls.
Diamond
Elvira
Hanover
Louisiana
Marguerite
Monticello
Moores Early
Mrs. Munson
Veeport
Vincent
Conderc 3306
N.Y. 12025
Solonis x Othello 1613

2

Delaware
XInta

3

Atoka
Bailey
Caco
Carman
Caywood
Kendaia
Naples
Ripley
Vergennes
Westfield

4

Brocton
Cloeta
Dunkirk
King Phillip
Wayne
Yates
N.Y. 12943
Vineland 35013
Vineland 292718

5

Alwood (1)
Buffalo (3)
Captivator (4)
Catawba (4)
Concord (1)
Fredonia (3)
Niagara (4)
Ontario (3)
Steuben (4)
Van Buren (1)
Worden (3)

6

Blue Eye
Eden
Hopkins
McCampbell
Moonbeam
Piney
Portland
Price
Red Giant
Urbana
Virginia
N.Y. 13038
N.Y. 20114
Couderc 3309
Vineland 37031
Vineland 51011
Vineland 52082
Vineland 53043
Vineland 53091
Riparia Gloire
Teleki 5BB
Teleki 5C

7

Dutchess
Missouri Riesling

8

Dearing
Ellen Scott
Eumelan
Hunt
Moored
Scuppernong
Venture
Aramon Rupestris Ganzin #1
Rupestris St. George
Solonis x Riparia 1616

Score

1 No damage
2 Slight bud mortality
3 Moderate bud mortality
4 Severe bud mortality
5 Trunk bark blackened
   and recovered
6 Water sprouts from crown
7 Suckers from roots
8 Dead vine
( ) Score for other vine

THE IMPORTANCE OF WINE ANALYSIS

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A winemaker who does not employ analytical techniques to determine the composition of the must and follow the course of the fermentation to completion is much like a pilot who is flying "by the seat of his pants". He may do all right the majority of the time, but sooner or later it will catch up to him. The composition and quality of the wine will depend upon the composition of the must; therefore, the winemaker should have a knowledge of the composition of that must. Proper interpretation of the information derived from the analysis of the must will allow the winemaker to treat this material so that the best quality of wine may be obtained. Several texts include methods of wine analysis (1,2,3). They work in close cooperation with the AOAC to revise and update the section on alcoholic beverages in their standard methods of analysis. As well as a guide to the winemaker, analytical results are required to meet the legal limits placed on certain wine components, such as alcohol, sulfur dioxide, sorbate, and volatile acidity.

This report will discuss the various methods which are available to the winemaker and relate their application to the overall wine making process.

Soluble solids

The most important analysis used in the winemaking process is the determination of soluble solids. Approximately 90% of these solids are fermentable sugars. While the soluble solids may vary between 13 to 25%, a good average for this area would be 16 to 18%.

There are several methods of determining the soluble solids content of the must. There are chemical methods for the reducing sugars by copper reduction; however, these methods are time consuming and require highly trained personnel. The methods used by the majority of the winemakers are the physical methods based on specific gravity and refractive index. The simplest method being the hand-held refractometer, which reads directly in percent sugar or degrees Brix. The specific gravity method, which is the most commonly employed method, uses a hydrometer suspended in the juice and calibrated to indicate grams of sucrose per 100 g juice.

An analysis for the soluble solids content would immediately indicate to the winemaker the need to add additional sugar and that his final concentration of alcohol would reach an acceptable level. This would be required, since, as previously stated, the fermentable sugar in the must are lower than that required for the optimum alcohol level, usually 12%.

Alcohol

The majority of the wineries use the Ebulliometer for the routine analysis of alcohol in wines. The Ebulliometer is an instrument for the determination of the boiling point. Any substance dissolved in water will alter the boiling point of the water. By measuring the boiling point of the wine, compared to water, we can determine the alcohol content of the wine, provided that the wine is dry. Sugar will also cause an alteration of the boiling point. If sugar is present in the wine and the alcohol is to be determined by the boiling point method, then the wine must

be distilled to separate the non-volatile material from the alcohol.

The alcohol concentration of the wine is important for two reasons: 1) the legal requirements, and 2) the stability of the wine. The legal requirements as applied to table wines give a maximum of 14% alcohol. Further alcohol concentration contained in a wine can vary plus or minus 0.5% of the concentration of alcohol listed on the label. If the alcohol concentration is below 10%, the wine is more susceptible to spoilage.

pH

The pH is measured by using a pH meter. The pH of the wine is influenced by a combination of the acids, primarily malic and tartaric, and the cations, particularly potassium. The combination of a weak organic acid together with its salt gives the buffering capacity to the wine. The pH of the wine has an effect on the wine color and stability, both tartrate and microbial. At a low pH, the red wines possess more brightness than the higher pH wines. This is particularly true of the rose wines where a more pronounced pink color is observed with a low pH wine. The tartrate stability is affected since the amount of the total tartrate existing as the bitartrate ion is a function of the pH. The more bitartrate ion which is present in the presence of potassium ion, the larger amount of tartrate precipitation will result. The same factor is true of the microbial stability. The higher the pH, the greater the amount of bisulfite that has to be added to the wine to achieve the same amount of free SO_2. According to Kunkee, at a pH of 3.3, 30 parts per million of free sulfur dioxide is required for microbial stability. However, at a pH of 4.0 using the same criteria, 110 parts per million of free SO_2 would be required. Again the concentration of sulfur dioxide as compared to the bisulfite present is a function of the pH.

Total Acidity

The total acidity is in reality the total titratable acid calculated as tartaric acid. This method is a neutralization reaction with sodium hydroxide to a phenolphthalein endpoint (pH 8.3). The endpoint is easily detected in a white must or wine; however, a red must or wine presents some problems due to the compounding of color of the must or wine.

Total acidity measures the free acid present in the wine, although the results are given as % tartaric acid. The total acidity is important in determining the amount of amelioration of the must, since the amelioration regulations are based upon the acidity. The main reason we are allowed to ameliorate wines with water is due to the fact that our wines are high acid. We will find a lowering of the total acidity when the fermentation is complete since during the course of this process the malate concentration will decrease by 10 to 30% while the tartrate will decrease considerably due to the precipitation of the potassium bitartrate. The total acidity also serves as an indication of the degree of tartness in the wine.

The total acidity is also used to determine the degree of neutralization of a wine with calcium carbonate.

Volatile Acidity

The volatile acidity content of the wine is a very important measurement. Federal and State laws have established legal limits for the amount of volatile acidity in wines. The maximum volatile acidity, calculated as acetic, which is permitted by federal standards is 0.140 g/100 ml for red table wines. A high volatile acidity

content is usually correlated with acetic acid spoilage due to the bacteria, Aceto-
bacter. Small quantities of acetic acid are produced during the normal fermenta-
tion process, usually between 0.03 and 0.05 g/100 ml. However, if the volatile
acidity increases, it is a good indication that some acetic acid spoilage is taking
place. This is a warning sign to the winemaker to check sanitation practices as
well as cleaning up his equipment. Sulfur dioxide will curtail the growth of the
Acetobacter as well as the elimination of air. There have been many batches of wine
which have ended as vinegar stock because of negligence in the lack of this determi-
nation. There have also been many shipments of wine refused by states having liquor
control boards because of the volatile acidity defect.

Sulfur Dioxide

Sulfur dioxide is used to control unwanted microbial and chemical changes during
the wine processing and aging. It exists in wines in three general states which are
of particular interest to the enologist. These states are called the total sulfur
dioxide, free sulfur dioxide, and the bound sulfur dioxide. Aldehydes, ketones, and
hemiacetals, which are natural constituents of the wine react with sulfur dioxide to
produce what is called bound sulfur dioxide. All the sulfur dioxide which is not
bound is defined as the free sulfur dioxide. The total sulfur dioxide is all the
sulfur dioxide present in the wine--both free and bound.

In wines, two forms of sulfur dioxide which are of greatest interest to the en-
ologist are the free and total sulfur dioxide. It is the free sulfur dioxide that
functions as the antiseptic and antioxidant in wine processing. The total sulfur
dioxide is important because many governments specify a maximum amount of total
sulfur dioxide allowable in the wines. In the United States, the maximum total sul-
fur dioxide allowable is 350 mg/l or 350 parts/million.

Summary

The use of analytical methods to aid the winemaker in producing a quality wine
have been discussed. Although we have discussed the major methods, there are other
methods which can be employed to add to the knowledge of the product as well as aid
in the production of the wine; for example, tartrate and potassium determination
for tartrate stability.

Basically the wine analysis gives the winemaker three pieces of information:
1) where am I?, 2) where am I going?, and 3) did I get there?

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MICROBIOLOGICAL STABILITY OF WINES

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Over the years, our laboratory has conducted microbiological analyses on wines at various stages of production. Recently, we have examined a large number of bottled wines from various countries. The following is a brief quantitative analysis of the microbiological content of bottled wines. The categories of wine examined included low alcohol, crackling, rosé, sparkling, red table, white table, aperitif, vermouth, flavored wine, wine cocktail and fruit wine.

No Viable Counts

Out of 500 bottles examined, 100 (20%) did not contain viable microorganisms.

Viable Counts

Out of 500 bottles examined, 400 (80%) contained viable microorganisms. Table 1 indicates the percent occurrence of various types of microorganisms in those bottles with viable counts. Bacteria were present 82% of the time, molds 39% and yeasts 32%. Clearly, bacteria occur most frequently in bottled wines.

Table 2 shows the frequency of occurrence of various ranges of viable counts. With molds and yeasts, the majority of the bottles contained 10 or less viable cells per 100 ml. The products which have greatest potential for presenting a refermentation problem are those containing more than 100 viable yeasts per 100 ml.

Combination of Types of Viable Microorganisms

Table 3 shows the combination of types of viable microorganisms occurring in bottled wines. The most frequent combinations are bacteria alone (42%); molds plus bacteria (16%); yeasts and bacteria (12%), etc. It is very important for even a small winery to determine the type and combinations of viable microorganisms present in the product so that an effective stabilization procedure can be established. For example, sorbic acid is more effective against yeasts than bacteria.

Shelf Life Studies

Our laboratory has been conducting shelf life studies on wines. The aim of the work is to study the effect of various storage conditions on the viable counts.

Table 4 shows the effect of 1 month's storage at 27°C on viable yeast counts. Samples 1, 2 and 3 were from the same product from the same bottling run. After 1 month, the count in two samples went up while the count in one decreased (but was still a high count). Clearly, the stabilization procedure for this product was not sufficient to prevent the subsequent growth of yeasts.

Samples 4, 5 and 6 were another product with high initial counts. The stabilization of this product was sufficient to reduce the viable yeast counts to zero.

Table 5 shows the effect of one month's storage at 27°C on viable bacteria counts. After 1 month, the counts in the red table and rosé wine samples decreased.

Essentially, Tables 4 and 5 suggest that if microorganisms are present at bot-

tling, the winery should hold the products for a period of time. This will allow the winery to determine whether the viable counts have a chance of increasing or decreasing.

No doubt, each winery, whether large or small, would like to know what acceptable viable counts for a bottled wine should be. This is not an easy question to answer. Theoretically, if a spoilage organism is present and if conditions are right, a single cell can multiply and cause subsequent spoilage. Perhaps, the best practical approach for any winery is to conduct viable counts on each bottling run. Over a long period of time, the winery will know what the normal viable counts are for the product in question. If the viable counts are higher than normal, the winery should put the product aside to see what happens to it.

The best advice for a small winery to follow is no matter what viable counts you have in your products, do your utmost to reduce those counts in the future.

TABLE 1. Occurrence of individual types of microorganisms in bottle wines*

Type	Occurrence
Molds	39%
Yeasts	32%
Bacteria	82%

*Based on 400 bottled wines containing viable microorganisms.

TABLE 2. Frequency of range of viable counts in contaminated wines.

Range of counts per 100 ml	% Frequency		
	Molds	Yeasts	Bacteria
1 - 10	80	69	44
11 - 100	13	25	48
101 +	7	6	8
Total	100	100	100

TABLE 3. Combination of types of viable microorganisms in bottled wines*

Combination	Number of bottles	Percent of total
Molds + yeasts + bacteria	45	11
Molds + yeasts only	4	1
Molds + bacteria only	65	16
Yeasts + bacteria only	49	12
Molds only	40	10
Yeasts only	29	7
Bacteria only	168	42
TOTAL	400	100

* Based on 400 bottled wines containing viable organisms.

TABLE 4. Effect of 1 month's storage at 27°C on viable yeast counts.

Sample	Viable yeast count per 100 ml	
	Control	1 Month
1 (Red table)	9,664	101,400
2 "	11,560	TNTC*
3 "	5,268	705
4 "	3,548	0
5 "	1,868	0
6 "	6,532	0

* TNTC = Too numerous to count

TABLE 5. Effect of 1 month's storage at 27°C on viable bacteria counts.

Sample	Bacteria count per 100 ml	
	Control	1 Month
1 (Red table)	96	24
2 "	88	44
3 "	92	24
4 (Rose)	192	136
5 "	240	140
6 "	188	120

PHENOLOGICAL DEVELOPMENT AND FROST HARDINESS OF GRAPE SHOOTS [1]

James B. Mowry [2]
Carbondale, Illinois

The temperature and precipitation at Carbondale, Illinois for the winter and spring months of 1976 are summarized in Table 1. January was cooler and drier than the normal or long-term means since 1893. Although the -562.5 Algebraic Degree Days $\pm$ 50°F (ADD) nearly equalled the normal -560.3 ADD, most of January temperature parameters were lower than normal. The minimum temperature -4°F (Grass Temperature -8°F) on January 9 was the lowest temperature of the 1975-76 winter. January precipitation was 1.15 inches (including .02 inches melted snow) compared with the normal 3.42 inches (including 3.42 inches melted snow).

February was much warmer and drier than normal. All the temperature parameters were much higher than normal. The minimum temperature was 8°F. February precipitation was 2.12 inches compared with the normal 2.75 inches. A total of 78 Growing Degree Days 50°F (GDD) accumulated in February. Bud dormancy of many fruit cultivars and ornamental shrubs was broken 1 week earlier than the very early dates of 1974 and approximately 1 month earlier than the anticipated average budbreak date of most years.

March was also much warmer and drier than normal, and the 102 ADD was a new record, higher than the normal -173.3 ADD. All the temperature parameters were much higher than normal (Table 1). The maximum temperature was 77°F, and the minimum temperature was 22°F. A total of 168 GDD accumulated in March. March precipitation was 2.69 inches compared with the normal 4.21 inches.

The probability of freezes at Carbondale, Illinois is shown in Table 2 (1). The temperature used for probability calculations were the official shelter air temperatures at first order weather stations in Illinois. However, Grass Temperatures (GT) observed on minimum-registering thermometers located 1 foot above grade in the vineyard more accurately indicated the temperatures to which the vines were exposed.

Concord buds broke dormancy on March 22 when a total of 192 GDD had accumulated since January 1. Many grape cultivars with complex American species parentage (American Hybrids (AH) were in the downy stage of bud development. Most cultivars with notable _Vitis vinifera_ parentage (Vinifera Hybrids (VH) had buds in the delayed dormant stage, and Vinifera (V) cultivars were still dormant. A light freeze of 29°F (GT 22°F) was observed on March 22, when the freeze probability was 75%, 3 in 4 years (Table 2). No freeze damage to grape cultivars was observed from this freeze, because the prevalent early bud development stages were not sensitive to this temperature.

On March 28, when 31 GDD had accumulated after Concord budbreak, most grape cultivars had advanced to the next stage of development; i.e., from downy buds to budburst. On March 30 (54 GDD) many cultivars again advanced to the next stage; i.e., from budburst to half inch green shoot.

The April temperature parameters were very close to normal, but precipitation was much lower than normal (Table 1). The minimum temperature was 29°F. A total

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of 254.5 GDD accumulated in April. On April 2 (54 GDD after Concord budbreak) many AH cultivars were in the budburst to half inch green stage, and a few cultivars had advanced to the 3/4 inch green stage. Many VH cultivars were slightly later in development, in the downy bud to budburst stage. Most Vinifera cultivars were dormant, except for a few in the downy bud stage.

On April 5 (82 GDD) a 29°F (GT 23°F), with 6 hours below 32°F, was observed. The probability of a 28°F freeze on this date was 25%, 1 in 4 years (Table 2). On April 10 (99 GDD) a very few cultivars showed slight advancement in bud development, but most cultivars were in the same stage of development observed on April 2 and 5, commonly budburst to half inch green on the AH cultivars. Another light freeze of 30°F (GT 23°F), with 6 hours below 32°F, was observed on April 10. On this date the 32°F freeze probability was estimated as 60%, 3 in 5 years. The probability of a 28°F freeze was estimated at 20%, 1 in 5 years (Table 2).

Most cultivars in the budburst or earlier stages of development were not visibly damaged by the freezes of April 5 and 10. Cultivars in the half inch green or later stages of development commonly were damaged by these freezes: Baco Noir, Chancellor, Fredonia, Himrod, Marechal Foch, Monticello, Ontario, Van Buren, XInta and NY GR 7 (Table 3). Representative cultivars which were not damaged by the April 5 and 10 freezes included: Agawam, Bath, Brocton, Caco, Cayuga White, Diamond, Ventura, Vincent, Villard Noir, Seyval, LeSuberaux and Vidal 256. When vines of the same cultivar were in slightly different bud development states, such as budburst and half inch green, only the more advanced stage was damaged: Beta, Buffalo, Champanel, Concord, De Chaunac, Delaware, Seneca, Steuben, Suffolk Red, Rosette and Veeport. Cultivars in the half inch green or more advanced stages and not damaged included: Bailey, Leon Millot, Schuyler, Worden and NY 12025. Cultivars damaged in the budburst stage included: Alden, Aurore, Catawba, Chelois, Louisiana, Niagara, Totmur, Villard Blanc and Castel 19637.

On April 13 (112 GDD) another 29°F (GT 22°F) freeze, with 6 hours below 32°F, was observed. The probability of this 32°F freeze was 50%, 1 in 2 years; for a 28°F freeze the probability was approximately 12%, 1 in 8 years (Table 2). The majority of grape cultivars were not damaged by this freeze. However, some cultivars with more advanced development were damaged: Baco Noir, Brighton, Buffalo, Concord, Niagara, Schuyler, Seneca, Sheridan, Steuben, Suffolk Red, Van Buren, Virginia, Villard Blanc and Worden.
On Ap
On April 17 (154 GDD) the buds of most AH cultivars had advanced considerably from the half inch green to 2 inch shoots. The VH cultivars bud development ranged from budburst to 1 inch shoots. A few Vinifera cultivars had buds in budburst, but the vines of many Vinifera cultivars had been killed to the ground as the result of the -4°F (GT -8°F) temperature on January 9. On April 22 (252 GDD) and the AH and VH cultivars had shoots 3 to 6 inches long, and the recovering Vinifera cultivars had 1 to 2 inch shoots. Root suckers were observed emerging from many of the own-rooted Vinifera cultivars which had been killed to the ground.

On April 29 (308 GDD) a 32°F (GT 25°F) freeze, with 4 hours below 32°F, damaged some cultivars which had shoots 4 to 10 inches long. The probability of this 32°F freeze was approximately 12%, 1 in 8 years (Table 2). In April a total of 5 freezes which damaged developing buds or shoots of grape cultivars was observed.

May was cooler than normal with normal precipitation (Table 1). All the temperature parameters were lower than normal, and the minimum temperature was 32°F. The 357 ADD was considerably lower than the normal 487.7 ADD. A total of 361.5 GDD accumulated in May. On May 3 (325 GDD) a 32°F (GT 25°F) radiation freeze, with 6

hours below 32°F, was observed, and on May 4 (325 GDD) another 32°F (GT 26°F) freeze, with 10 hours below 32°F, occurred. The probability of this freeze was approximately 15%, 1 in 7 years (Table 2). These freezes damaged 4 to 8 inch shoots of many cultivars. On May 9 (364 GDD) a 33°F (GT 26°F) radiation freeze, with 8 hours below 32°F, caused additional damage to shoots 15 to 18 inches long (Table 4). The probability of this freeze was 4%, 1 in 25 years (Table 2). On May 24 (741 GDD after Concord budbreak) first bloom anthesis was observed on Concord and many other cultivars (Table 5).

The cold temperatures in the spring of 1976 would be classified as light freezes, considering the official shelter air temperatures (1). However, the Grass Temperatures affecting the vines would be classified as moderate to severe freezes. The temperatures observed and the stages of bud development both influenced the degree of damage sustained by the vines. Undoubtedly, a number of cultivars escaped damaging temperatures because of relatively late developing buds. The early bud development stages before budburst, or the first appearance of green leaf tissue, were more resistant to cold damage (Table 3).

The cold tolerance of the cultivars was expressed most clearly when all the cultivars had green shoots exposed to the freezes in early May (Table 4). The following cultivars were not damaged by any of the freezes in 1976: Alwood, Canada Muscat, Moores Early, Romulus, Rougeon, Humbert 3, NY GW 5, NY GW 9, NY 36661, Seibel 14117, Seyve-Villard 5247, Rubired and Ruby Cabernet.

In 1976 the last freeze was observed on May 9, which was 10 days before first bloom anthesis occurred on Champanel on May 15, the earliest bloom. A summary of the first bloom anthesis of the grape cultivars and damage from the freezes of 1976 at Carbondale, Illinois, is listed in Table 5. Although the 1976 season started very early, the grape bloom season was close to the usual anticipated grape bloom period in an "average" or normal year.

At Carbondale, the mean probability (50% or 1 in 2 years) of the last 32°F freeze is on April 15; for the last 28°F freeze, the date is March 31. The Grass Temperatures affecting the vines may be expected to be 5 or 6°F lower (approximately 23°F) than the official shelter temperature under radiation freeze conditions with clear night skies and little or no wind. Selection of grape cultivars with freeze tolerance and vineyard sites with good air drainage would be very advantageous to the grower.

LITERATURE CITED

1. Joos, L. A. 1960. Freeze probabilities in Illinois. Ill. Agr. Exp. Sta. Bul. 650: 1-16.

TABLE 1. Normal and 1976 Temperatures and Precipitation at Carbondale, Illinois

| | Temperatures °F | | | | | | | | | | | | | Precipitation Inches | |
| | Mean | | Mean Max | | Mean Min | | ADD[1] | | GDD[2] | 1976 24-Hr | | | | | |
	1976	Norm	1976	Norm	1976	Norm	1976	Norm	1976	Max	Min	Grass	1976	Norm
Jan	31.9	34.3	42.2	43.3	21.5	25.1	-562.5	-560.3	0	59	-4	-8	1.15	3.42
Feb	44.2	37.0	56.0	47.2	32.6	27.9	-167.5	-393.8	78	74	8	6	2.12	2.75
Mar	53.3	46.3	66.2	57.0	40.6	35.6	102.0	-173.3	168	77	22	17	2.69	4.21
Apr	57.8	57.1	71.7	68.4	43.9	46.2	234.0	217.1	255	85	29	23	.99	4.29
May	61.5	66.5	74.3	77.9	48.7	54.6	357.0	487.7	361	86	32	25	4.59	4.54

1 Algebraic Degree Days ± 50F: The Algebraic Sum (Daily Mean Temp -50F = ADD)

2 Growing Degree Days 50F: The Sum (Daily Mean Temp 50F -50F = GDD)

TABLE 2. Probability of first and last freeze dates (1) at Carbondale, Illinois

| Temperature | Last Freeze Probability in Spring | | | | |
	75% 3 in 4 yrs.	50% 1 in 2 yrs.	25% 1 in 4 yrs.	10% 1 in 10 yrs.	5% 1 in 20 yrs.
32F	4/6	4/15	4/24	5/2	5/7
28F	3/22	3/31	4/8	4/16	4/21
24F	3/9	3/18	3/27	4/4	4/9
20F	2/25	3/6	3/15	3/23	3/28
16F	2/13	2/22	3/3	3/11	3/16

Temperature	First Freeze Probability in Fall				
32F	10/29	10/20	10/11	10/4	9/29
28F	11/16	11/7	10/20	10/22	10/17
24F	12/23	11/14	11/5	10/29	10/24
20F	12/4	11/25	11/16	11/9	11/4
16F	12/16	12/7	11/28	11/21	11/11

TABLE 3. Grape cultivars escaping* freeze damage after Grass Temperature 23F
on April 10, 1976 at Carbondale, Illinois

Bud Development April 10				
Delayed Dormant	Downy Bud	Bud Burst	Half Inch	3/4 Inch
*Aligote	*Beacon	*Agawam	Alden	Baco Noir
*Baco Blanc	*Caco	*Alwood	*Bailey	Fredonia
*Century 1	*Cayuga White	*Atoka	Beta	Himrod
*Dearing	*Cloeta	Aurore	Buffalo	Lakemont
*French Colombard	*Colobel	*Bath	Captivator	Marechel Foch
*Glenora	*Dunkirk	*Brighton	Carman	Ontario
*Keuka	*Gaertner	*Brocton	Catawba	Seneca
*Le Commandant	*Lady Patricia	*Canada Muscat	Champanel	Van Buren
*McCampbell	*Landal	*Canadice	Chancellor	
*Ripley	*Moores Early	*Caywood	Concord	
*Ruby Cabernet	*Mrs. Munson	Chelois	De Chaunac	
*Scuppernong	*Price	*Concord Sdls.	Delaware	
*Vignoles	*Riparia Gloire	*Diamond	Dutchess	
*Zinfandel	*Red Giant	*Golden Muscat	Eumelan	
*Landot 4511	*Rougeon	*Interlaken Sdls.	Hanover	
*NY GR 8	*Royalty	*Kendaia	Hopkins	
*NY GW 5	*Rubired	*King Philip	Lindley	
*NY GW 8	*Salem	*Le Suberaux	Louisiana	
*NY GW 9	*Westfield	*Leon Millot	Marguerite	
*NY 12943	*Yates	*Lindley	Monticello	
*S 10076	*BS 2846	*Moonbeam	Niagara	
*V 35013	*JS 12428	*Naples	Rosette	
*V 27031	*JS 26627	*New York Muscat	Roubideaux	
	*NY 18080	*Piney	*Schuyler	
	*NY 25542	Portland	Steuben	
	*NY 36661	*Seyval	Suffolk Red	
	*S 7136	*Sheridan	Totmur	
	*SV 23512	*Veltliner	Valerien	
	*V 51011	*Ventura	Veeport	
		*Verdelet	Wayne	
		*Vergennes	Worden	
		Villard Blanc	Xlnta	
		*Villard Noir	NY GR 3	
		*Vincent	NY GR 7	
		*Virginia	*NY GW 4	
		Castel 19637	*NY 12025	
		*Humbert 3	NY 13038	
		*JS 23416	NY 15302	
		NY GR 1	NY 18135	
		*NY GW 10	SV 12413	
		*NY 20114	V 49063	
		*S 14117	V 52082	
		*SV 5247	V 292718	
		*Vidal 256		
		V 53043		
		*V 53091		

TABLE 4. Freeze damage scores of grape cultivars after Grass Temperature 26°F on May 9, 1976 at Carbondale, Illinois

Inches Shoot Length on May 11

2	4	6	8	10	12	15	18
Score 0 Lakemont NY GW 9 Score 1 Dearing Score 4 Interlaken Sdls.	Score 0 Muscat St. Vallier Landot 4511 Riparia Gloire Rubired Ruby Cabernet S 7136 S 12481 S 14117 Score 1 Canadice Cayuga White Scuppernong Ventura Verdelet Vidal 256 V 35013 Score 2 Chancellor Keuka V 37031 Score 3 Aligote Glenora NY 36661 Score 0 No damage 1 Leaf bronzing 2 Leaves killed	Score 0 Humbert 3 NY GW 5 Score 1 Cloeta French Colombard LeCommandant Salem Veltliner Vignoles Yates Castel 19637 JS 23416 NY GR 3 NY 25542 S 10076 V 52082 V 53043	Score 0 Canada Muscat Hanover Monticello Moores Early Price Rougeon SV 5247 Score 1 Brocton Century 1 Dunkirk Gaertner Mrs. Munson Wayne NY GR 7 NY GW 10 V 49063 Score 2 Baco Blanc Landal Van Buren Vergennes Zinfandel JS 26627 Score 3 Seneca Roubideaux Veeport	Score 0 Red Giant Villard Noir NY GW 4 SV 12413 Score 1 Agawam Bailey Caco Caywood Colobel Diamond King Philip Moonbeam Piney Rosette Royalty Valerien Westfield BS 2846 JS 12428 SV 23512 Score 2 Golden Muscat Himrod NY GR 1 NY GR 8 Score 3 Dutchess Eumelan	Score 0 Alwood Portland SV 12303 Score 1 Captivator Champanel DeChaunac LeSuberaux Louisiana Marechal Foch Marguerite Seyval Vincent XInta NY 12025 NY 13038 NY 15302 NY 20114 Score 2 Alden Beta Brighton Buffalo Chelois Concord Naples Ripley Schuyler S 13047 Score 3 Bath Carman	Score 1 Catawba Delaware NY 18135 Score 2 Concord Sdls. Hopkins McCampbell Ontario Score 3 Suffolk Red Virginia	Score 1 Aurore Beacon NY 12943 Score 2 Niagara Villard Blanc Score 3 Baco Noir Lindley

TABLE 4. Freeze damage scores of grape cultivars after Grass Temperature 26°F on May 9, 1976 at Carbondale, Illinois

Inches Shoot Length on May 11							
2	4	6	8	10	12	15	18
Score 0	Score 0	Score 0	Score 0	Score 0	Score 3	Score 1	Score 1
	3 Shoot tip or flowers killed				Kendaia		
	4 Shoots killed				Sheridan		
					Steuben		
					Worden		
					NY 18080		

TABLE 5. Date of first bloom anthesis and freeze damage score for 140 grape cultivars after Grass Temperature 26°F on May 9, 1976 at Carbondale, Illinois

May 15		May 24		May 25		May 31	
Champanel*	1	Alden*	2	Agawam	1	Atoka	3
		Alwood	0	Naples	2	Carman*	3
May 19		Aurore*	1	Rosette	1	Cloeta	1
Beta*	2	Baco Blanc	2	Roubideaux*	3	Keuka	2
Concord Sdls.	2	Bath	3	Seneca*	3	Louisiana*	1
Marguerite*	1	Brighton	2	Veltliner	1	Romulus	0
Worden	3	Buffalo*	2	V 35013	1	Royalty	1
		Canadice	1	V 51011	2	Veeport*	3
May 20		Chelois*	2			Vignoles	1
Baco Noir*	3	Colobel	1			NY GR 3*	1
Captivator*	1	DeChaunac	1	**May 26**		NY 13038	1
NY GR 7*	1	Delaware*	1	Century 1	1	SV 5247	0
		Dutchess*	3	French	1	SV 12303	2
May 21		Fredonia*	3	Colombard		SV 12413	1
Catawba*	1	Golden Muscat	2	Lady Patricia	2	V 53043*	1
Concord*	2	Interlaken	4	Sheridan	3	V 53091	2
Hopkins	2	Sdls		Valerien	1		
King Philip	1	Kendaia	3	Ventura	1	**June 2**	
Vincent	1	Lakemont*	1	JS 23416	1	Villard	
NY 12025	1	Leon Millot	2	NY GW 5	0	Blanc*	2
NY 20114	1	Marechal Foch*	1	NY 36661	0	NY 15302*	1
		Monticello*	0	S 10076	1		
		Moonbeam	1	V 37031	2	**June 4**	
May 23		Moores Early	0	V 49063*	2	Eumelan*	3
Bailey	1	Mrs. Munson	1			Rubired	0
Beacon	1	NY Muscat	2	**May 27**		Ruby	
Caco	1	Niagara*	3	Brocton	1	Cabernet	0
Caywood	1	Ontario*	2	Canada Muscat	0	Virginia	3
Diamond	1	Piney	1	Cayuga White	1	Zinfandel	2
Dunkirk	1	Portland*	0	Chancellor*	2	NY GW 9	0
Gaertner	1	Salem	1	Hanover*	0	S 7136	0
Landal	2	Schuyler	2	Himrod*	2	S 12481	2
LeCommandant	1	Steuben*	3	LeSuberaux	1	S 14117	0
Lindley*	3	Suffolk Red*	3	Seyval	1		
Rougeon	0	Van Buren*	2	Wayne*	1	**June 7**	
Totmur	2	Westfield	1	JS 12428	1	Verdelet	1
Vergennes	2	BS 2846	1	Landot 4511	1		
Xlnta*	1	Castel 19637	1	NY GR 8	2		
Yates	1	Humbert 3	0	NY 18080	3		
BS 2862	1	NY GW 4	1	V 52082*	2		
JS 26627	2	NY GW 10	1				
S 13047	2	SV 23512	1				
Villard Noir*	0	Vidal 256	1				
		V 292718*	2				

Score
0 No Damage
1 Leaf Bronzing
2 Leaves killed
3 Shoot tip or flowers killed
4 Shoots killed
* Freeze Damage April 10

REMOVING DISSOLVED OXYGEN FROM WINES

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There are two sources from which oxygen can be absorbed into wine: (1) atmospheric oxygen resulting from contact between the product and air in the container head space; (2) the dissolved oxygen in the product itself coming from improper handling. Example: Top filling a barrel instead of bottom filling, and pulling air in on the suction side of a pump during transferring or blending. Normally wines properly handled contain less than one part per million of dissolved oxygen. Readings could be all the way down to zero under excellent conditions.

The one sure way of preventing this from happening is proper handling. In cases where this cannot be accomplished, two methods can be adopted to reduce the amount of oxygen pickup. Blanketing is an expensive, but flexible means of preventing any pick up of oxygen resulting from contact between product and air. Blanketing is simply filling the head space of the wine container with low pressure inert nitrogen gas rather than air bearing oxygen.

Sparging, which is an inexpensive and the most modern method of removing dissolved gases from flowing liquids. The inland sparger works by passing nitrogen gas through a porous metal cylinder suspended in the product. Injections of minute nitrogen bubbles into the product flow stream, results in a super-saturated solution of nitrogen and product. As the small bubbles of nitrogen are distributed throughout the liquid, a difference in partial pressure is created between the nitrogen and oxygen.

This difference in partial pressure causes the dissolved oxygen to leave the fluid. When these bubbles rise to the surface, as in a storage tank, the oxygen and nitrogen is effectively removed. The efficiency of the stripping or sparging effect is dependent on two factors. The first is nitrogen bubble size, the smaller the size for a given quantity of gas the larger the interfacial area available for stripping out of oxygen. The second is the amount of time these bubbles are exposed to the oxygen. The longer this period the more effective the sparging process.

How much gas will it require to remove 7-9 ppm of oxygen from 1,000 gal. of wine? The minimum size pump required will be 30 gal. per minute. In a little over one hour of circulation with only 30 cfp/hour of nitrogen flowing you will remove the dissolved oxygen from 9 ppm to 1 ppm. An example for the cost of nitrogen would be anywhere between $1.50 P 100 cf and $4.00 P 100 cf. A large cylinder will hold approximately 300 cf. So one cylinder of gas can efficiently remove 8 ppm of dissolved oxygen from 10,000 gal. of wine for a cost between $4.50-$12.00

In blanketing, as a rule of thumb--one cubic foot of nitrogen equals 7 volume changes per gallon. Example: A 1,000 gal. vessel that is full to 900 gals. The remaining 100 gals, if displaced by 100 cf of nitrogen, equals 7 volume changes, which will give you less than one percent oxygen concentration in air above the wine.

Effect of Flavor

Because of nitrogen being inert, it does not react with the wine to change its flavor. It does not stay dissolved in the wine, like CO_2 does. In other words, nitrogen does not dissolve readily in a liquid. A test was conducted in a small

winery using one 30 gal. barrel of wine. Prior to sparging the oxygen content of the wine was .7 ppm. This wine was handled correctly throughout its fermentation process. Before sparging, 4 bottles of wine were first pulled from the barrel. It is to be noted, at this time, although there was very little oxygen in the wine, there still was some CO_2 left from the fermentation process. This was a very young wine. After sparging, the oxygen content was 0 and there was no noticeable CO_2. Observing two bottles next to each other and at the same temperature, shows the sparged bottle to have more of a crystal clarity. The reason for this is not quite understood. Customers were asked to sample both wines and to give their comments--50% liked sparged and 50% liked the other, so there was nothing conclusive from the test. But, it does indicate no flavor loss because of the sparging.

The ideal condition for bottling is first to purge to bottle, have sparged wine, and have a nitrogen purged head space. California eliminates the first step because of the high cost of purging bottles. Their process will double the shelf life where a good complete process will give 3-4 times the shelf life. This is an advantage, especially in the 20% commercial wines that may show high oxidation or change of color in 4-6 months, if the wine has not been sparged. It appears by processing the white wines they receive the greatest benefits. This is due to the fact that their color is maintained for a greater period of time.

BIOLOGICAL DEACIDIFICATION IN OHIO WINES

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Studies concerning biological deacidification of Ohio red table wines were undertaken during the 1976 vintage. These studies involved two biological methods: bacteria and yeast fermentation of malic acid. The bacterial deacidification is termed malo-lactic fermentation and is the conversion of malic acid to lactic acid and carbon dioxide by certain lactic acid bacteria. Although malo-lactic fermentation is usually beneficial in reducing high wine acidity, the initiation of bacterial deacidification is often difficult. Many factors influence this fermentation in wines, such as temperature, aeration, alcohol content, time of racking, and sulfur dioxide. In addition, bacteria capable of malo-lactic fermentation often are not tolerant to low pH and high acidity. These latter factors are usually characteristic of wines made from certain Ohio grapes.

The other biological deacidification method is the degradation of malic acid through fermentation by Schizosaccharomyces pombe. This yeast has the ability to metabolize malic acid to ethanol and carbon dioxide. Through the reduction of malic acid, wine acidity is reduced. However, a primary drawback of this yeast is the production of off-flavors and aromas during wine fermentation.

This report will summarize the findings of two studies at OARDC. The first investigation was designed to determine the effect of time of bacterial inoculation on the induction of malo-lactic fermentation. The other study was devoted to an effort of limiting the production of off-flavors and aromas by Schizo. pombe. For this investigation, the yeasts (Schizo. pombe) were removed after a partial fermentation, and the fermenting wines were reinoculated with Sacch. cerevisiae.

Malo-Lactic Fermentation

This study was initiated to determine the effectiveness of encouraging malo-lactic fermentation in red table wines by inoculation with lactic acid bacteria. The investigation included the evaluation of inoculating with Leuconostoc oenos (PSU-1) before, during, and after alcoholic fermentation on the rate of malo-lactic fermentation.

In 1976, grapes from the varieties DeChaunac and Chancellor were harvested from a commercial vineyard in southern Ohio. After the grapes were destemmed and crushed, the musts were ameliorated with sugar to bring the soluble solids content to 20%. Then, the musts were treated with 50 ppm of sulfur dioxide in the form of potassium metabisulfite. Twelve hours after the sulfur dioxide treatment, the musts of each variety were divided into four lots and inoculated with a 1% (v/v) active yeast culture (Montrachet #522). One lot of each variety was used as a control, and the other three lots were inoculated with 2% bacteria culture at different stages of alcoholic fermentation (approximately 20°, 8°, and -1.0° Brix). The fermenting musts were stirred twice daily and were pressed about 3 days after yeast inoculation. All wines were fermented in glass carboys equipped with "water seals" and placed in 18°C storage. The wines were fermented to dryness, racked, and stored full in glass containers. After malo-lactic fermentation, the wines were racked, cold stabilized, bottled, and stored at 18°C.

Must analyses indicated that the varieties were high in total acidity, DeChaunac, 1.25%, and Chelois, 1.21% (Table 1). The pH of both must samples were ap-

proximately the same, 3.11 (DeChaunac) and 3.10 (Chelois). These values are low, because their must acidities were relatively high.

TABLE 1. Effect of Time of Bacterial Inoculation on the Rate of Malo-Lactic Fermentation

Time of Inoculation	pH	Total acidity %	Days to complete M-L fermentation
		DeChaunac	
Must	3.11	1.25	----
Control*	3.52	0.74	126***
Before**	3.52	0.77	126***
During**	3.56	0.76	47
After**	3.56	0.76	48
		Chelois	
Must	3.10	1.21	----
Control*	3.55	0.67	126***
Before**	3.57	0.66	126***
During**	3.56	0.67	70
After**	3.56	0.67	59

*   Sample taken after malo-lactic fermentation (natural).
**   Stage of alcoholic fermentation.
***   Malo-lactic fermentation occurred after 126 days.

The stimulation of malo-lactic fermentation was obtained by inoculating with Leuconostoc oenos during or after alcoholic fermentation. Malo-lactic fermentation was also present in control wines, but was found to be much slower. For example, the natural malo-lactic fermentation of the variety DeChaunac was completed after 126 days, whereas wines inoculated during and after yeast fermentation occurred in 47 and 48 days, respectively. Similar results were obtained for the Chelois wines; however, the greatest stimulation was found in wines inoculated after alcoholic fermentation. As expected, the loss of malic acid during malo-lactic fermentation plus a decrease in tartrates during cold stabilization brought the wine acidities into a more acceptable level.

Schizosaccharomyces pombe

Grapes from the white variety Seyval were harvested in 1976 from a commercial vineyard in southern Ohio. After the grapes were destemmed and crushed, the must was analyzed for total acidity, pH, and soluble solids. The must was then treated with 100 ppm of sulfur dioxide in the form of potassium metabisulfite. Upon pressing, the juice was ameliorated with sugar to bring the soluble solids to 21%. Twelve hours after the sulfur dioxide treatment, the juice was divided into 6 lots (15 l each). Two lots were used as control samples and were inoculated with active yeast cultures of Schizo. pombe and Sac. cerevisiae (2% v/v). The other 4 lots were also inoculated with Schizo. pombe. However, these lots were fermented for only 1, 2, 4, and 6 days, respectively. After each time interval, the yeast cells of Schizo.

pombe were allowed to settle by placing the wines in 4°C storage. Then, the partially fermented wines were racked into glass carboys and re-inoculated with Sac. cerevisiae. All wines were stored at 18°C for fermentation. When the wines reached dryness, they were racked and treated with sulfur dioxide. After additional rackings (during a 6 month period), the wines clarified with bentonite and filtered. The wines were then cold stabilized, bottled, and evaluated after 6 months storage.

The results of the chemical analyses for the various wines are shown in Table 2. Wines fermented solely or partially with Schizo. pombe were lower in total acidity than the Sac.-fermented wine (control). The Sac.-fermented wine contained 0.76% total acidity while the Schizo.-fermented wines ranged between 0.68% and 0.41%.

TABLE 2. Chemical Analysis and Sensory Evaluation of Wines Fermented with Sac. cerevisiae, Schizo. pombe, and Schizo. pombe Reinoculated with Sac. cerevisiae at Varying Time Intervals.

Treatments	Total[a] acidity	pH	Malic acid (%)	Aroma[b]	Taste[b]
Fresh Must	0.96	3.14	0.52	---	---
Sac. cerevisiae	0.76	3.14	0.34	4.5	3.5
Schizo. pombe	0.43	3.38	0.01	1.9	1.9
Schizo.-Sac. (1 day)	0.68	3.19	0.29	4.6	3.9
Schizo.-Sac. (2 day)	0.62	3.24	0.29	4.6	3.8
Schizo.-Sac. (4 day)	0.41	3.36	0.03	3.4	2.7
Schizo. Sac. (6 day)	0.41	3.33	0.01	3.4	2.9

a Titratable acidity as g tartaric acid per 100 ml.
b 7-point hedonic scale, 7 being the most acceptable.

The Schizo. fermentation also brought about an increase in pH through the loss in total acidity, mainly malic acid. The largest percentage of malic acid decomposition was found in the wine fermented solely with Schizo. pombe, 98%. For the wines ino-culated with 2 yeasts, the amount of malic acid reduction was related to the length of Schizo.fermentation. Partial fermentation of 4 and 6 days with Schizo. pombe was found to be lowest in malic acid content.

Results of the sensory evaluations indicated that wines fermented solely with Schizo. pombe were ranked lowest in aroma and taste. The best wines for both quality attributes were those fermented with Sac. cerevisiae and Schizo. pombe at 1 and 2 days. Taste panel results also indicated that the aroma scores dropped off as the length of Schizo. contact time was increased. The 4 and 6 days Schizo.-fermented wines were ranked poor for both aroma and taste.

Based on the results of this investigation and by other researchers, further studies are needed before recommending Schizo. fermentation as a method of wine de-acidification. Future studies at OARDC will involve the evaluation of several strains of Schizo. pombe in reducing wine acidity.

GRAPE WEED CONTROL WITH HERBICIDES

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Chemical weed control on grapes is widely accepted. It has been used for approximately 30 years and continues to increase. Chemicals, including simazine, diuron, DNBP, paraquat, and dichlobenil have become extensively used. Grapes are relatively tolerant to vineyard applications and by following manufacturers recommendations, acceptable control can generally be obtained.

Any weed control chemical in order to perform properly must be applied properly and under rather specific conditions. No single herbicide will provide complete selective weed control in all situations. For most effective response, chemical weed control programs usually require a combination or alteration of various herbicide treatments. Use of the same chemical year after year will generally result in some problems.

Herbicide Classification

Herbicides employed in grape vineyards fall in three main categories and are applied either before or after weed emergence. 1) Pre-emergence herbicides are soil-active, controlling weeds germinating from seeds for a period of a few weeks to a full season; 2) post-emergence contact, which destroy above ground protions; or 3) translocated herbicides, which are foliar active and affect all parts of the plant.

Contact Herbicides:

Most contact herbicides are soluble in water. They perform essentially the same function as cultivation, except the soil is not disturbed.

A single spray application with complete coverage by a contact herbicide kills susceptible annual weeds. However, a series of treatments are required to kill each successive generation of annual weeds and for perennial weed control.

Translocated Herbicides:

Translocated herbicides, as the term implies, are applied to one plant part, where they are absorbed by the tissue and are translocated to other tissues and organs. Examples of these types are glyphosate, Dowpon and 2,4-D. These systemic herbicides are generally absorbed by the leaves and moved through the plant tissues into roots and rhizomes. This group of herbicides have greater effectiveness in killing perennials that have strong regenerating capabilities. In most cases complete foliage coverage is not required.

Soil-Active Herbicides:

The principle soil-active herbicides, used in Ohio vineyards, are diuron (Karmex) and simazine (Princep). They generally remain effective (active) in the soil for several months and are very useful in grape vineyards requiring continuous weed control. In fact, care must be taken when replants are placed in such soil to see that this active material is not mixed in the hole with the plant. Soil-active herbicides kill plants by absorption through their root system or underground organs. Other

soil-active herbicides, such as methyl bromide, vorlex and other fumigants of this type are retained in the soil for only a brief period, but tend to kill many types of organisms including diseases and insects as well as weeds.

Herbicide Selectivity

One of the major breakthroughs in chemical weed control, as we know it today, came with the development of 2,4-D. Because with it, true selectivity was obtained. Today the primary basis for use of agricultural herbicides is still selectivity. That is, the ability of a chemical to kill one plant and not another. Selectivity can be obtained by several means; formulation, concentration or dosage, method of application, local environmental conditions, differences in rates of translocation and metabolism and biochemistry of the various plant species.

Foliar-Active Herbicides:

Grape vines need not be directly tolerant to foliage applications of contact or foliar systemic herbicides, since these chemicals can be selectively applied to just the weed growth with only minor spray drift or wetting of sucker shoots and foliage that gets in the wetting path.

Soil-Active Herbicides:

Examination of any weed control manual will convince anyone that there are many soil-active herbicides available on the market. Many are too toxic to grapevines. Several others have never been cleared for use in vineyards, although they appear to have merit. Still others are not labeled for use until the plantings are in their 3rd year even though the risk involved appears small. A grapevine's tolerance to most, if not all, soil-active herbicides is relative and not complete. Solubility of the herbicide, or lack of solubility, which prevents the herbicide from moving into the root zone of the grape is an important factor. Overdoses of these herbicides may severely injury or kill vines of they are not properly applied. Injury symptoms, for example, frequently appear at the ends of rows when extra material is applied due to stopping, starting, or turning with the equipment. Under field conditions, injury symptoms are sometimes difficult to distinguish from other abnormalities such as insects, diseases or nutritional differences or excesses. Excessive residues of these materials are not likely to appear in the fruit, unless sprayed directly on them.

Herbicide uptake by the vines may vary with vineyards because toxicity of herbicides varies with the nature of the soil. Sandy soils, for example, or soils low in organic matter, are apt to produce more toxicity than soils high in clay or organic matter. There are often inter-relations among cation-exchange capacity, organic matter, clay content, and herbicide in soil solution, which in turn affect a herbicide phytotoxicity to grape vines as well as the weeds.

Persistance of herbicides in the soil also varies from one vineyard to another. Soil classification, based upon particle size does not give a reliable index of a herbicide's resistance. Soil-active herbicides are degraded by micro-organisms. Thus, the persistance of a herbicide is related to the presence of the organism capable of metabolizing the herbicide as well as the conditions favorable for the growth of the organisms. This persistance is often related more to the soils biological and environmental characteristics than to its physical and chemical characteristics.

Herbicide Weed Control Programs

The most effective weed control program a grape grower can have is one that utilizes all applicable methods. This can vary from vineyard to vineyard depending upon the weeds, soil conditions, climatic conditions and the degree of weed control desired. While suitable and approved soil-active herbicides generally form the bases for the overall program, contact or translocated herbicides are also usually necessary to control persistant annuals and established perennials.

Soil-Active Herbicides: Soil-active herbicides are widely used in Ohio's vineyards and viticultural areas. In a typical program, the herbicides are applied in early spring before weeds have become established (preferably before they germinate). Adequate rainfall most always occurs at this time of year to move it into the zone where the seeds germinate.

The dosage required to kill weeds is lowest when the weeds are young and increase as the plant grows older. Under average vineyard conditions about 3 to 4 pounds active ingredient of simazine or diuron/acre are required to control the susceptible annual weed species. If weeds are growing which are resistant to the herbicide in use, a change to a different herbicide may be required. In fact, changing from one herbicide to another as a routine practice every few years is a desirable procedure. Using dosages that are too low tends to encourage escaping weed species. A higher treatment rate will generally increase the effectiveness on these species but care needs to be used to avoid toxicity. Weed species that are resistant to a herbicide will rapidly become dominant in the absence of competition from more susceptible weeds.

Contact Herbicides: There are many situations in weed control programs where contact herbicides are a necessary supplement to the soil-active herbicides. In newly planted vineyards these herbicides can be used to control weeds growing in the area where soil-active herbicides cannot be used safely. They can also be used as a final clean up of scattered weeds not controlled by the soil-active herbicide application. However, one of the most effective uses of contact herbicides is in conjunction with soil-active herbicides. Both can be applied together when weeds are actively growing in early spring, thus combining both types of killing action into one spray. Application of soil-active herbicides can thus be delayed and still achieve effective control. Another use of a contact herbicide is to apply it in midsummer after the spring applied soil-active herbicides are beginning to loose their effectiveness. Such an application will allow sufficient time for the crop to mature or canopy shading will prevent the weeds from competing adversely.

Paraquat when applied at a rate of 2 quarts per sprayed acre is effective in killing or supressing most annual and perennial broadleaves and grassy weeds. The addition of a surfactant is necessary to aaaure its effectiveness in wetting and coverage of the foliage.

In broadcast or spot treatments with contact herbicides, there are considerable advantages in treating weed growth when it is in a young stage of development. Early treatment reduces the total volume of spray material required to achieve control. Many weedy plants are more easily wet and killed by applying the herbicide during their seedling stage.

A New Herbicide for Vineyard Weed Control

Effective and economic control of perennial weeds has remained a persistant weakness of chemical weed control programs in Ohio vineyards. As control of annual weeds

have occurred, perennial weeds have even grown more prolific. Herbicides to control the perennial weeds, such as brambles, bindweed, quackgrass, Johnson grass, poison ivy, etc., have generally been rejected because they were ineffective or because of the poor margin of safety they offered to the crops. The results obtained by multiple use of contact herbicides or physical removal has often been poor either because of cost or lack of effective control.

Glyphosate

Extensive testing of glyphosate (N(phosphonomethyl)glycen) (Roundup) in Ohio grape vineyards under an experimental label has demonstrated that it can be used safely and effectively in controlling many of the persistant perennial weeds provided certain strict precautions are followed. Glyphosate is a water-soluble material that is applied to the foliage. The material then enters the plant through the leaves or other above ground parts and is translocated to the underground roots or stem tissues.

Visible response after glyphosate is applied is rather slow and varies with plant species, age, size and weather conditions. Annual plants will begin to wilt 3 to 5 days after application but some perennials such as brambles will only show chlorosis or leaf burn symptoms for the remainder of the season. However, as translocation to roots, rhizomes and other underground parts occurs, growth is halted and regeneration the following season fails to occur. In general, there is little or no activity of the herbicide through the soil. In tests at the Southern Branch, re-growth through the seed has shown no glyphosate effect. The use of a soil-active herbicides for pre-emergence effect or a contact herbicide for post-emergence effect is necessary for season long control. Re-application of glyphosate is also possible as frequently as desired.

Vine Safety

As mentioned above, experimental tests at OARDC have shown glyphosate can be used safely in vineyards provided a few strict procedures are followed. At present this material is not approved for use in Ohio vineyards. The approved use of glyphosate at the present time is limited to pre-plant applications. However, it is hoped that in the near future label approval will be granted.

Since glyphosate is a translocated foliar applied herbicide, firm precautions must be made not to apply it on grape vine tissue that will allow it to be translocated into the plant. In general, this includes leaf tissue of sufficient maturity that the carbohydrates produced within the leaves are not translocated to other parts of the vine. In the illustrations to follow some of the dramatic affects of glyphosate on brambles are shown. These were conducted in commercial vineyards under the experimental use label.

A vineyard that failed due to poor weed control.

A productive vineyard under sod and chemical weed control in So. Ohio.

A young vineyard with rows maintained by paraquat; a contact herbicide.

A tractor mounted weed sprayer. Observe off-set spray nozzle on boom.

Symptoms of diuron (Karmex) foliage injury on grapes.

Symptoms of simazine (Princep) foliage injury on grapes.

Bramble problems in mature grape vineyards in Ohio. See effect of Roundup treatment in the same vineyards in photos below.

Untreated control row (left) vs. Roundup treated row (right) one year following application.

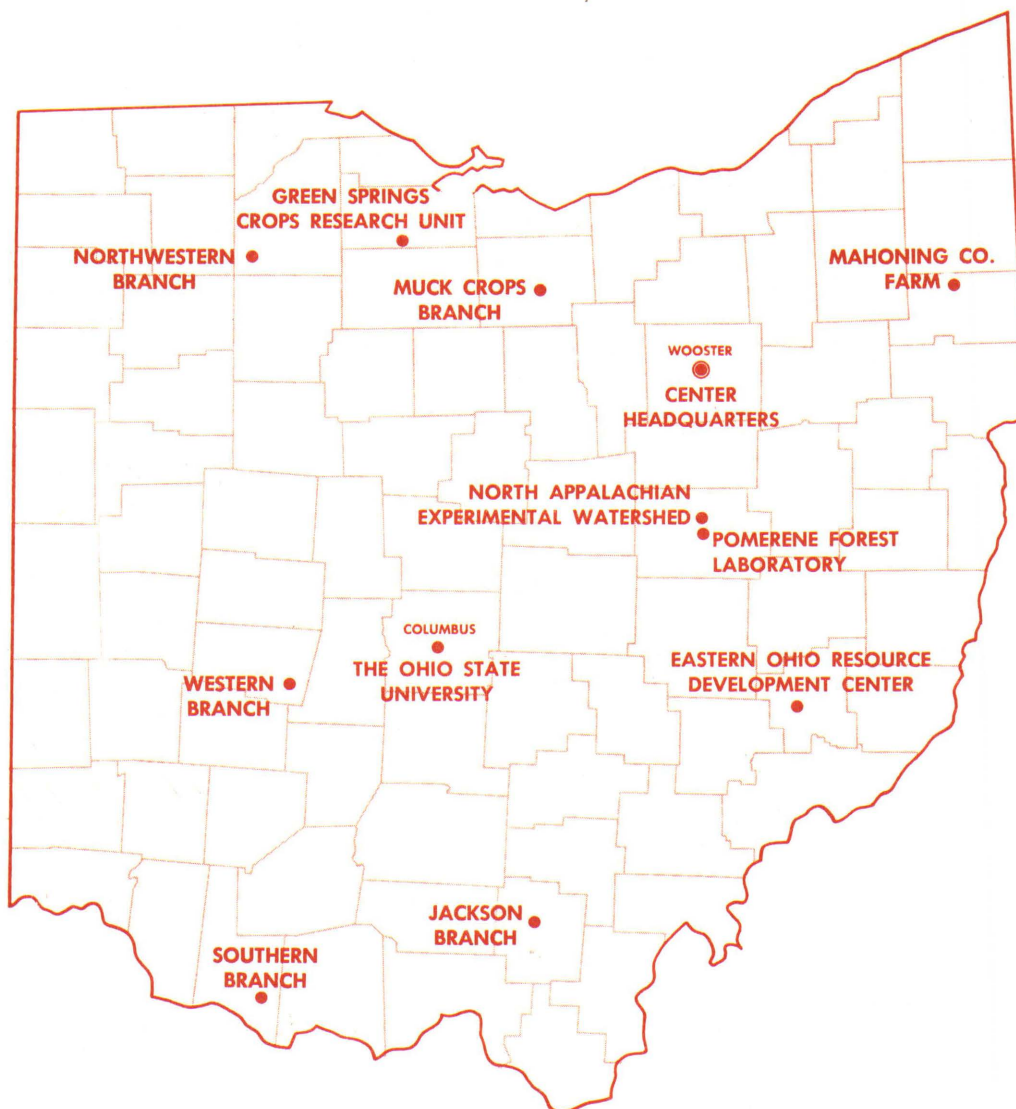Untreated control row (center) vs. Roundup treated rows one year following application.

Stunting & yellowing effect of Roundup following application to brambles.

Hemp dogbane two months after treatment with Roundup.

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Ohio's major soil types and climatic conditions are represented at the Research Center's 12 locations.

Research is conducted by 15 departments on more than 7000 acres at Center headquarters in Wooster, seven branches, Green Springs Crops Research Unit, Pomerene Forest Laboratory, North Appalachian Experimental Watershed, and The Ohio State University.

Center Headquarters, Wooster, Wayne County: 1953 acres

Eastern Ohio Resource Development Center, Caldwell, Noble County: 2053 acres

Green Springs Crops Research Unit, Green Springs, Sandusky County: 26 acres

Jackson Branch, Jackson, Jackson County: 502 acres

Mahoning County Farm, Canfield: 275 acres

Muck Crops Branch, Willard, Huron County: 15 acres

North Appalachian Experimental Watershed, Coshocton, Coshocton County: 1047 acres (Cooperative with Agricultural Research Service, U. S. Dept. of Agriculture)

Northwestern Branch, Hoytville, Wood County: 247 acres

Pomerene Forest Laboratory, Coshocton County: 227 acres

Southern Branch, Ripley, Brown County: 275 acres

Western Branch, South Charleston, Clark County: 428 acres