THE POTENTIAL OF WINE-GRAPE PRODUCTION IN THE SAN JOAQUIN DELTA AREA OF CALIFORNIA

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ABSTRACT

The San Joaquin Delta of California is a new area for wine-grape production. Climate, soils, and fruit quality were investigated from 1965 through 1967.

The climate as measured by degree-days was found to be essentially the same as in the Lodi (California) district and varies from year to year between Temperature Regions III and IV. Although only 15 to 20 miles from the Lodi district, the Delta has cooler days and warmer nights during the growing season. There is evidence that in hot years the Delta climate is cooler than the Lodi climate.

The vineyards are on Ryde series soils, which are unique in a number of ways. They are medium-textured alluvial soils that occur as narrow, meandering bodies standing higher than the surrounding peat soils. The surface is highly acid, varies in organic-matter content from 10% to 20%, and is generally very loose and friable. The soils are irregularly stratified with respect to such properties as pH, organic matter, salinity, texture, and nutrient status. The soils are usually well drained, because of their higher position. Subsoil pH's can run as low as 3.4, but no adverse vine nutritional problems have been observed.

Analysis of the expressed juice from berries sampled from 10 varieties showed the balling-acid ratio for some varieties to be satisfactory for table wines. Varieties tested that may have a potential in the Delta are: 'Chenin blanc,' 'Grey Riesling,' 'Petite Sirah,' 'Helena,' and 'White Riesling.' Vines were vigorous and produced good yields.

The San Joaquin Delta region is located at the confluence of the Sacramento and San Joaquin Rivers, in the Central Valley of California, east of the San Francisco Bay. The Delta consists of a group of islands that are below sea level, protected by levees from flooding. The islands are predominantly organic soils which were formed on deposits of tule-reed peat, but mineral soils also exist on these islands at slightly higher elevations. To date, the agriculture of these areas has been entirely field and vegetable crops. Amerine and Winkler conducted extensive testing of wine-grape quality throughout California's viticulture regions, but the Delta was not included in their study because of lack of vineyards (3, 4). In 1959, an experimental planting of grapes was made on the levees of Mandeville Island in San Joaquin County by Zuckerman-Mandeville Inc., to determine the feasibility of grapes for the Delta. Subsequently, in 1963, a 4.5-acre wine-variety trial of certified vines was planted on mineral soils within the island. In 1964, a small commercial planting was established near the wine-variety trial. Mandeville's climate and soil and the quality of its grapes were investigated from 1965 to 1967. Climate and soil comparisons were made between the Delta district and the nearest established grape district, at Lodi, 17 miles northeast of Mandeville.

MATERIALS AND METHODS

Soils: The soil type on which the variety trial and commercial planting were established was Ryde silty clay loam. This determination was based on the soil map from USDA Soil Survey of the Sacramento-San Joaquin Delta Area, California Series 1935, No. 21. Profile samples for analyses were taken at one-foot intervals to a depth of five feet from 14 locations in three different fields and analyzed by standard methods at the University of California Agricultural Extention Laboratory, Davis. Analyses were run for pH, salinity and sodium status, organic matter, texture, and the nutrients NO_3, P, and K. Similar samples were taken from four locations in a typical Lodi-district vineyard and analyzed for comparison.

Vine Nutrition: Petioles were collected from six varieties within the variety trial on Mandeville Island during 1965 through 1967. They were taken opposite to the basal clusters at full bloom. The University of California Agricultural Extension Laboratory, Davis, analyzed these petioles by standard procedures for nine of the important elements.

Climate: Thermographs were placed in standard U. S. Weather Bureau shelters within the Wine-Grape Variety Trial on Mandeville Island and in a Lodi-district vineyard. The thermographs were calibrated before installation and checked weekly with a mercury-in-glass thermometer. Continuous temperature records were taken from April 1 through October 31 during 1965, 1966, and 1967.

Degree days, mean maximum and minimum temperatures, and hours above 80, 90, and 100°F were calculated for this period. Degree days were calculated by multiplying the monthly mean temperature, less 50°F by the number of days in the month (7).

Fruit Quality: Fruit quality determinations were made by collecting 100-berry samples and analyzing the expressed juice for degree balling, total acids, and pH.

The random berry-sampling procedure was to take a single berry from various positions within the cluster and throughout the vine as described by Amerine and Roessler (2). Sampling began when the degree balling approached 16° and was repeated weekly until harvest. Samples were taken to the laboratory and run within three hours of picking. The unwashed berries were crushed, so as not to break the seeds, in a large mortar and pestle. The juice was then filtered and squeezed through four thicknesses of cheesecloth. Degree balling was determined with a hand refractometer calibrated for temperature corrections. Total acids (expressed as grams tartaric per 100 ml) were determined by titrating with 0.133 NaOH to an end point of pH 8.4 with a glass-electrode pH meter (1). The pH of expressed juice was measured with a Corning pH meter, model 7.

RESULTS AND DISCUSSION

Soils: The soils of this area, primarily organic, were formed on deposits of tule-reed peat accumulated over a long period under water-logged conditions. The area is composed of dozens of islands and a network of surrounding rivers and sloughs. Prior to reclamation, these islands, which vary in size from a few hundred to several thousand acres, were at essentially sea level and were inundated twice a day by fresh water at high tides. Following reclamation by levee building around the turn of the century, however, the elevation inside the levees began to drop as a result of a number of factors, particularly the shrinkage of organic sediments due to dewatering, compaction from heavy equipment, and biologic oxidation of these materials as a result of the improved aeration. As a result, the elevation of these islands today ranges to more than 15 feet below sea level, representing an average annual subsidence rate of 2-3 inches per year during the past four decades (5, 9).

The soils on which the grape plantings were established are the remains of old sloughs and their stream banks, which once meandered across the islands. These Ryde soils have a higher mineral content and exist at a slightly higher elevation than the surrounding organic soils. This higher elevation (as a result of the continuing subsidence of the more organic soils) results in a deeper water table and improved drainage. The water table is generally 5 feet or deeper.

The soils under study are relatively acid, the surface soils ranging from pH 4.2 to 6.1, with most of them around pH 5.0 to 5.5. Table 1 shows the analyses of selected profiles. The subsoils are more acid than the surface, typically running from pH 4.0 to 4.5, with some samples running as low as pH 3.4. The lowest pH's (below 4.0) are associated with neither the very high nor the relatively low organic matter content, which varied considerably in the profile.

Organic-matter content of the surface soil in the Variety Trial ranged from 15 to 21%, while that of the commercial vineyard was somewhat lower, at 12 to 16%. This organic matter has a profound effect on the physical nature of the soil, which, by definition, from organic-matter-free mechanical analysis runs from sandy loam to loam. This organic matter appears to add nutritional and water-holding properties comparable to those of a heavier soil while retaining the handling ease and water penetration of the lighter soil. The soil is difficult to puddle or compact. The subsoil contains 10 to 20% organic matter except where occasional lenses or substrata of fibrous peat raise the organic matter content to over 50%. Grape roots readily penetrate the subsoil, including the fibrous peat. It is possible that this high organic matter content is the only reason the grape roots can tolerate the low pH in the subsoil so well.

Delta soils are well known for their rare property of combining a salinity hazard with acid pH. The Ryde soils in this experiment are no exception. The

TABLE 1

Soil Analyses from Selected Sites in Commercial Vineyards and Wine Variety Trial, Mandeville Island — March 1965, Ryde Silty Clay Loam

Location	and depth (ft)	Mechanical analyses texture	pH	ECe (Millimhos)	Ca+Mg (me/l)	Na (me/l)	SAR	OM (%)	NO_3-N (ppm)
Site #2	0-1	Loam	5.8	0.61	4.4	2	1	13.0	32.0
	1-2	Sandy loam	4.5	0.90	6.0	3	2	14.3	52.0
	2-3	Loam	4.0	0.77	4.4	3	2	11.2	44.0
	3-4	Loam	4.1	0.79	4.6	3	2	10.6	38.0
	4-5	Loam	4.3	0.87	5.6	3	2	10.9	36.0
Site #5	0-1	Sandy loam	4.2	1.78	14.8	3	1	15.7	94.0
	1-2	Sandy loam	3.6	1.40	9.4	5	2	19.0	80.0
	2-3	Sandy loam	3.4	2.10	16.0	12	4	16.8	78.0
	3-4	Loamy sand	3.5	4.40	56.0	15	3	28.4	23.0
	4-5	Loamy sand	5.0	3.20	42.0	7	2	38.4	4.6
Site #7	0-1	Sandy loam	6.1	0.72	5.0	2	1	20.6	17.0
	1-2	Sandy loam	5.7	0.81	5.0	3	2	20.2	20.0
	2-3	Loam	4.3	0.93	5.6	4	2	11.6	21.0
	3-4	Loam	4.2	0.96	5.8	4	2	8.0	12.0
	4-5	Loam	4.2	1.04	7.4	3	2	10.0	4.2

salinity hazard is reduced, however, by their somewhat elevated position and lower water table. Most of the sampling sites produced samples with an EC_e ranging from a little below 1 to 2 millimhos. (EC_e is the specific conductivity in millimhos/cm of the soil saturation extract and is a measure of soil salinity.) One surface sample and a few subsoil samples were in the range of 3 to 4 millimhos, where some loss of yield might be expected. There appears to be no serious salinity problem.

Ca, Mg, and Na were determined to assess alkalinity hazard. No sample produced a sodium absorption ratio (SAR) of more than 4, and most were less. (SAR is a ratio for soil extracts and irrigation waters used to express the relative activity of sodium ions in exchange reactions with soil. Sodium hazard requires an SAR of about 13 or more.) Thus, there was no sodium hazard in the soils tested.

As might be expected for a soil with so great a variability in organic matter, NO_3-N also showed a great variability, both within the profile and from one sampling site to another. Except for one sample, NO_3-N in March ran from about 5 ppm to nearly 100 ppm. These values can be expected to change throughout the season, however, perhaps drastically, because of the large nitrogen reserve in the organic matter.

Table 2 shows the analysis of a typical Lodi vineyard soil in an old established wine-growing district. This Hanford loam is less acid, has lower salinity, and is far lower in organic matter and NO_3-N content than the Ryde series of the Delta. In addition, the Hanford soil is more uniform with depth. Analyses of three other Hanford profiles in the same vicinity varied little from the data shown here, as distinguished from the high variability apparently characteristic of the Ryde soils.

Although there are 47,000 acres of soil in the Delta mapped as Ryde, including 11,500 acres of Ryde silty clay loam (the mapped type of soil under present study), only 5 or 10% of this appears in the San Joaquin River part of the Delta, as old meandering sloughs similar to the present study site. The remainder exists as large bodies in the Sacramento River portion of the Delta, associated with the Columbia soils. The wide variations of the Delta soils will require careful examination and possibly grape test plots to determine the extent and location of soils suitable for vineyard production. The potential of the bulk of the organic soils in the Delta for grape production would appear doubtful because of high water tables, often fluctuating, and a continuing subsidence which would, in 10 to 20 years, expose a considerable portion of the root system.

Vine Nutrition: Tissue analyses indicated no vine nutritional problems for the three years tested. The 1967 analyses are shown in table 3. Also, foliar observations re-

TABLE 2

Soil Analyses from Selected Site in a Lodi District Vineyard April 1968

Hanford Loam

Location and depth (ft)	Texture	pH	ECe (Millimhos)	Ca+Mg (me/l)	Na (me/l)	SAR	OM (%)	NO_3-N (ppm)
Site #1								
0-1	Loam	6.2	0.25	1.5	1.0	1	1.7	3.6
1-2	Loam	6.4	0.30	1.7	1.3	1	0.8	4.2
2-3	Loam	6.6	0.37	2.0	1.7	2	0.5	4.2
3-4	Loam	6.7	0.31	1.5	1.6	2	0.3	2.1
4-5	Loam	7.0	0.30	0.9	2.1	5	0.6	2.3

TABLE 3

Tissue Analyses of Bloom-Time Petioles Collected from Variety Trial — Mandeville Island 1967

Variety	NO_3-N (ppm)	P (%)	K (%)	Ca (%)	Mg (%)	Na (%)	Cl (%)	B (ppm)	Zn (ppm)
'Grey Riesling'	4940	.48	2.70	2.64	.65	.03	.45	48	74
'Chenin blanc'	9360	.22	2.00	2.44	.93	.03	.40	42	77
'Petite Sirah'	4420	.18	2.25	3.72	.65	.03	.45	50	33
'Zinfandel'	5720	.36	3.95	2.62	.59	.04	.43	52	60
'Royalty'	4940	.69	3.75	1.78	.52	.04	.29	68	108
'Rubired'	2600	.31	2.30	1.81	.54	.04	.25	80	65

vealed no nutritional symptoms of excess or deficiency.

No fertilizers or lime were applied to these vines, and no nitrogen had been applied to the asparagus which preceded the grapes. Even so, the NO_3-N content of the petioles showed a substantial increase each year as the vines became older, as shown in table 4. The increases in NO_3-N content may be explained by the exploration of stratas of decomposing organic matter by the more extensive root systems of maturing vines. Cook and Kishaba (6) found that yields were reduced when nitrogen fertilizers were applied to vineyards already high in nitrate. At present, these vines are high in vigor, and the NO_3-N levels should be watched carefully. These vigorous head-trained vines may require management changes in training and trellising methods to utilize this vigor so that yields and fruit quality are optimum. Shaulis *et al.* (8) improved yields and quality of high-vigor Concord vines by changing from the conventional Umbrella-Kniffen training method to the Geneva Double-Curtain system.

TABLE 4

Nitrate Nitrogen Content (ppm) of Bloom-Time Petioles from Mandeville Island Variety Trial

Variety	Nitrate nitrogen (ppm) 1965	1966	1967
'Grey Riesling'	624	2756	4940
'Chenin blanc'	800	7332	9360
'Petite Sirah'	676	1248	4420
'Zinfandel'	1352	1768	5720
'Royalty'	2288	4732	4940
'Rubired'	884	1716	2600

Climate: Table 5 shows heat summation during the growing season, expressed as degree-days, for Mandeville Island and Lodi. In 1965, a relatively cool year, there was no difference between Mandeville Island and Lodi, with both having 3432 degree-days. In 1966, Mandeville had 3543 degree-days, 225 less than Lodi. Temperatures recorded in 1967 followed an atypical pattern, with April being the coolest on record and July and August among the hottest on record. The total degree-days in 1967 were 3482 for Mandeville Island, 158 less than for Lodi.

Although the climates of Mandeville Island and Lodi appear to be similar in terms of degree-days, Mandeville consistently had lower maximum temperature and higher minimums, as shown in table 6. This is probably explained by the cooling marine-weather influence during the daytime and the moderating influence of surrounding bodies of water at night. During the warmer months of June, July, and August, the daily maximums average 3 to 5 degrees cooler at Mandeville than Lodi. Conversely, except for October, Mandeville's daily average minimums run 1 to 3 degrees warmer than Lodi's.

The duration of high daytime temperatures is less at Mandeville than Lodi, as shown in table 7. Determination of the hours above 80, 90, and 100°F is a further refinement to indicate the true dif-

TABLE 5

Degree-Days Comparisons by Month, 1965, 1966, & 1967

	1965		1966		1967	
	Mandeville	Lodi	Mandeville	Lodi	Mandeville	Lodi
April	270.0	258.5	335.5	375.5	—11.0	0.0
May	442.5	412.5	450.0	493.5	425.5	447.0
June	460.0	481.5	565.5	589.0	497.0	545.5
July	667.5	693.0	577.5	617.0	748.0	781.5
August	691.5	711.5	705.0	747.0	781.5	810.5
September	447.5	453.0	573.0	591.5	636.0	669.0
October	453.0	421.5	336.5	354.0	404.5	386.0
Total	3432.0	3431.5	3543.0	3767.5	3481.5	3639.5

TABLE 6

Comparisons of Monthly Mean Daily Maximum and Minimum Temperatures (°F)

	Mandeville av. max.	Lodi av. max.	Diff. of max.	Mandeville av. min.	Lodi av. min.	Diff. of min.
1965						
April	68.8	69.6	—0.8	49.2	47.7	+1.5
May	79.1	80.8	—1.7	49.4	45.8	+3.6
June	78.6	82.7	—4.1	52.1	49.4	+2.7
July	87.2	91.4	—4.2	55.8	53.3	+2.5
August	87.4	90.3	—2.9	57.2	55.6	+1.6
September	80.2	83.1	—2.9	49.7	47.1	+2.6
October	80.9	82.6	—1.7	48.3	44.5	+3.8
1966						
April	75.7	79.3	—3.6	46.7	45.7	+1.0
May	78.0	83.2	—5.2	49.5	48.6	+0.9
June	83.6	87.4	—3.8	54.1	51.9	+2.2
July	85.0	88.3	—3.3	52.2	51.5	+0.7
August	89.3	93.6	—4.3	56.2	54.5	+1.7
September	84.4	87.9	—3.5	53.8	51.5	+2.3
October	74.9	79.7	—4.8	46.8	43.1	+3.7
1967						
April	57.8	58.5	—0.7	41.7	41.5	+0.2
May	77.4	81.0	—3.6	50.0	47.9	+2.1
June	79.4	84.8	—5.4	53.8	51.6	+2.2
July	90.3	94.5	—4.2	58.0	55.9	+2.1
August	90.8	95.4	—4.6	59.6	56.9	+2.7
September	85.1	89.4	—4.3	57.3	55.2	+2.1
October	77.5	81.4	—3.9	48.6	43.5	+5.1

ference between Mandeville and Lodi climates. In 1965, when degree-days were equal for those two locations, Mandeville had 309 fewer hours above 80°F and 160 fewer hours above 90°F. The trend was similar in 1966 and 1967.

Also in 1965, during the critical months of fruit maturation — July, August, and September — Mandeville had 5.8, 5.9, and 2.2 average hours per day of temperatures above 80°F, respectively, whereas Lodi had 8.0, 7.6, and 3.9. Although both locations fluctuate from year to year between Temperature Regions III and IV, the climate appears dissimilar. No comparisons were made of the organic acids and other maturity standards that affect wine quality, but it could be anticipated that the area with lower maximum temperatures and shorter duration of heat would have a better sugar-acid ratio for table wine production. These climate variations may be an important factor in the selection of varieties for the Delta area.

Wind: Although no comparative wind records were kept, wind effect on the vines was greater at Mandeville than at Lodi. Actual vine damage was minimal, but fruit tended to be exposed on the northwest corner of the head-trained vines. Other training methods might minimize this problem.

Fruit Maturity: Table 8 gives analyses of the expressed juice from berries sampled from 10 varieties on Mandeville Island. The data are from the last sample taken prior to harvest. A few samples did not reach maximum maturity because of an early harvest conducted by the grower.

The degree-balling shown for 1967 was lower than for previous years, because the experimental sampling was terminated prematurely by commercial harvest of the vines. The vines in this trial were pruned to produce propagation wood, and no effort was made to balance crop for quality.

Most of the varieties under test had a balling-acid ratio which is satisfactory for table wine production. Limited testing indicated that some of the varieties that may have a potential in the Delta are: 'Grey Riesling,' 'White Riesling,'

TABLE 7
Average Hours Per Day Above 80, 90, 100°F, by Month

	1965						1967					
	Mandeville			Lodi			Mandeville			Lodi		
	80	90	100	80	90	100	80	90	100	80	90	100
April	0.9	0.0	0.0	1.4	nil*	0.0	0.0	0.0	0.0	0.0	0.0	0.0
May	2.3	0.1	0.0	3.6	0.6	0.0	2.6	0.6	0.0	3.8	1.6	0.0
June	1.8	0.2	0.0	3.4	0.7	0.0	3.5	0.6	0.0	5.2	1.9	0.2
July	5.8	0.8	0.0	8.0	2.8	nil*	8.4	2.4	0.0	9.7	4.8	0.3
August	5.9	0.8	0.0	7.6	2.4	0.0	8.1	2.6	0.1	9.6	5.0	0.4
September	2.2	nil*	0.0	3.9	0.3	0.0	4.8	0.6	0.0	6.8	1.6	0.0
October	2.3	nil*	0.0	3.5	0.2	0.0	1.3	0.0	0.0	1.3	0.0	0.0

* More than 0.0 but less than 0.1.

TABLE 8

Analyses of the Expressed Juice from Berry Samples — Mandeville Island

Variety	1965				1966				1967			
	Date	°Bal.	TA	pH	Date	°Bal.	TA	pH	Date	°Bal.	TA	pH
'Grey Riesling'	8/27	21.6	.82	3.58	8/9	20.0	.74	3.70	8/31	19.8	.66	3.60
'Chenin blanc'	9/22	22.2	.76	3.46	9/6	20.0	.56	3.62	9/13	18.8	.81	3.25
'Petite Sirah'	9/22	22.8	.88	3.46	8/30	21.9	.78	3.42	9/27	19.0	.75	3.46
'Zinfandel'	9/22	19.1	.95	3.36	9/6	18.3	.76	3.63	9/27	19.0	.66	3.40
'Pinot St. George'	9/22	22.0	.84	3.78	8/23	20.2	.69	3.67	—	not sampled	—	—
'White Riesling'	9/15	21.0	.82	3.38	8/23	20.2	.83	3.37	9/6	19.6	.97	3.25
'Helena'	9/15	21.0	1.11	3.44	9/6	21.0	.78	3.48	9/27	20.0	.72	3.42
'Merlot'	9/15	22.4	.74	3.62	8/15	21.9	.87	3.53	9/6	21.6	.74	3.60
'Cabernet Sauvignon'	9/22	22.2	.95	3.40	9/20	21.6	.71	3.52	9/27	17.0	.82	3.40
'Muscat Canelli'	9/1	21.0	.77	3.37	8/30	22.8	.82	3.45	9/13	21.8	.83	3.38

'Helena,' 'Chenin blanc,' and 'Petite Sirah.' The present plantings of these varieties are vigorous and productive. Further investigations of wine quality from Mandeville Island are being conducted by the Department of Viticulture and Enology, University of California, Davis. Completion of this study should further clarify which varieties are most suitable.

The results of our investigation indicate that the Delta is an interesting and unique new grape-growing district. The soils are quite variable and very different from the usual California vineyard soils, particularly in their high organic-matter content, their low pH, and their high nitrogen-supplying capacity. The climate, which has a marine influence, is characterized by shorter duration of high daytime temperatures, lower maximums, and higher minimums than at the nearby Lodi district. The vines are vigorous and productive, and the fruit of most varieties tested had a balling-acid ratio suitable for table wine production.

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