



FIRST PRESS

NEWSLETTER OF OLIVE OIL PRODUCTION AND EVALUATION

Volume 3, Number 4

Summer '08

Verticillium Wilt of Olive

By Paul Vossen, Doug Gubler, and Miguel Angel Blanco



Verticillium wilt symptoms on a large tree

Verticillium wilt is a soil-borne fungus disease caused by the organism (*Verticillium dahliae*). It is one of the most serious diseases of olive trees worldwide because it can kill trees and is difficult or impossible to control. The presence of high levels of certain strains of *Verticillium* in soil effectively renders the land unusable for olive growing. Over 30 years ago we had entire table olive orchards in California that were destroyed from this disease. We have recently observed, in a few new orchards in California, that some trees have been positively identified as having *Verticillium*, so this disease must be taken seriously.

SYMPTOMS

Symptoms appear as wilting, leaf rolling, chlorosis, defoliation, and dead brown leaves remaining attached to the branches. On large trees, one or more branches suddenly wilt early in the growing season. Disease generally becomes worse as the season progresses. Yield from infected trees is poor. On very young trees, the whole tree begins to look pale and stops growing. The leaves wilt and the tree may die. Darkening of xylem tissue does not occur in olive wood as it does in other species. The most common symptom on all *Verticillium* infected trees is chlorosis (yellowing of the leaves) followed by defoliation. In some cases, very susceptible cultivars defoliate without leaf chlorosis. Sudden wilt, leaf rolling, and chlorosis is sometimes observed at the same time.

(*Verticillium*, Cont. on p.2)

Oil Crop for 08-09

The crop estimate came out a few weeks ago for the table olive industry, which estimated that crop at about 50% compared to last year. This year's table olive orchards should yield 65,000 tons, down from 132,500 tons in 2007. It appears that the Sevillano variety will be especially low. The oil olive crop, should fare quite a bit better, because the greater number of varieties were affected less by alternate bearing. There will also be an additional 2,000 acres of super-high-density orchards coming into production for the first time that were planted three years ago in 2005. This rise in production should continue for at least the next five years as the estimated 2,000 acres planted in 2006; 4,000 acres planted in 2007; and over 6,000 acres planted this summer (2008) all will be reaching full production.

California's estimated production of oil in 2007-08 was about 500,000 gallons and should reach 600,000 gallons this year. This is less than anticipated based on new acreage beginning to bear that should have brought over 200,000 gallons of new oil into California producer's tanks. This is due to several factors related to weather this spring. The different regions and varieties were affected differently with some areas hit by the April 20th freeze that turned a huge bloom into mediocre fruit set; this primarily occurred in the North Coast, Sacramento Valley, and Sierra Foothills. Other areas had a lighter bloom than last year due to typical alternation from one year to the next, got a pretty good set from the lighter bloom, but still have less fruit than last year. Many areas also saw a reduced set from the early season, dry soil conditions and hot, dry winds during bloom.



(Oil Crop, Cont. on page 8)

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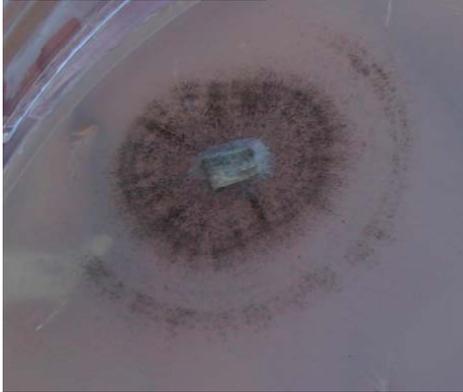
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(Verticillium, Cont. from p.1)

Verticillium wilt fungus growing on an agar plate



DISEASE DIAGNOSIS

Beyond symptoms, positive identification of the presence of *Verticillium* is typically done by placing thin pieces of infected vascular tissue onto specific types of agar culture medium. After about 4 days of incubation the fungus grows out and can be identified microscopically. Small black thick walled resting structures, called microsclerotia are formed and can be seen with a hand lens. A new technique for identifying the pathogen uses polymerase chain reaction (PCR)-quality DNA extracts. There are several vegetative compatibility groups that are specifically related to host plants. In olive there are two strains, defoliating and non-defoliating, that are quite different in their virulence.

DISEASE PROGRESSION

Verticillium wilt is favored by cool moist soils at temperatures ranging from (70-81° F). Root exudates in contact with microsclerotia stimulate germination, hyphal growth, and penetration into the root cortex and xylem cells (water conducting tissues). Inside the plant's vascular system fungal conidia are produced. The conidia are passed through the vessels where they often become trapped. Germination allows mycelium to pass through the ends of the vessels where the fungus once again produces conidia that move further up the xylem. This presence in the water

conducting tissue causes the tree to produce gums and tyloses in the vessels thus helping "wall off" or compartmentalize the infection. This also leads to further plugging of the xylem cells causing wilt and color loss in the upper part of the plant. The time from infection to first symptoms can be 3-30 weeks. Inside dying plant parts, the fungus produces microsclerotia, which are resting structures that can live for many years in the soil in dormancy after the plant decomposes. *Verticillium dahliae* microsclerotia (resistant spores) have been documented to survive for at least 30 years in the soil.

Some trees have been observed to recover naturally from an initial *Verticillium* infection. The degree of recovery depends on the strain of the fungus (defoliating or non-defoliating, the resistance of the cultivar, and inoculum density in the soil. Trees infected with the defoliating strain or infections in general in cultivars that are very susceptible to *Verticillium* rarely recover. In contrast, varieties that are more resistant or that have been infected by the non-defoliating strain of the disease often will recover (see table 1). The amount of inoculum in the soil has a significant effect on initial infection and reinfection rates.

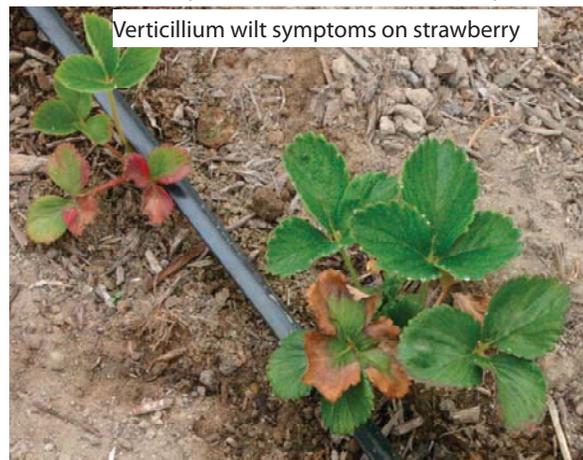
SPREAD OF THE PATHOGEN

This fungus does not have a known sexual stage. The hyphae produce conidia asexually and under conditions of fungal stress masses of microsclerotia are produced. *Verticillium* gets into soil from infected soil or plant material. Movement of soil by wind, water, or dirty equipment carries the fungus into uninfested soil. Spread can occur by bringing in non-symptomatic infected vegetatively propagated olive trees or other host plants grown as an intercrop. Host plants include many ornamental tree and herbaceous flower species; several vegetable crops: cabbage,



Verticillium wilt symptoms on a branch

celery, cucumber, eggplant, lettuce, melons, pepper, potato, pumpkin, radish, squash, tomato, and watermelon; several fruit crops: cane berries, Prunus species, Ribes species, grapes, and strawberry.



Verticillium wilt symptoms on strawberry

There are several common weed hosts including groundsel, lambsquarters, nightshade, pigweed, shepardspurse, and velvetleaf. Host plants can build up inoculum levels within the leaves, stems, and roots, which then contribute to the resting population in soils. Unfortunately, even non host plants such as grains and legumes may serve as a reservoir of the pathogen in some environments.

FIRST PRESS is produced by University of California Cooperative Extension 133 Aviation Blvd, Suite 109 Santa Rosa, CA 95403 707-565-2621 www.cesonoma.ucdavis.edu Paul Vossen, Farm Advisor

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(Verticillium, Cont. on p.3)

(*Verticillium*, Cont. from p.2)

DISEASE PREVENTION and MANAGEMENT

The best way to prevent this disease is to make sure that *Verticillium* microsclerotia are not present in the soil of any prospective orchard. This is usually done by staying away from land that had been planted to crops that are highly susceptible to *Verticillium* wilt, such as cotton, cucurbits, eggplant, peppers, potato, or tomato. The soil can also be tested. For susceptible cultivars, the two most important factors to consider are (1) the strain of the fungus (defoliating or non-defoliating) and (2) the amount of inoculum expressed as number of microsclerotia per gram of soil. Almost any level of infestation (inoculum density) in the soil can cause significant disease problems in olives especially if the defoliating strain is involved or if very susceptible cultivars are grown. Recent research in Spain has shown that when the number of defoliating strain microsclerotia per gram of soil exceeds 3.33 the disease incidence can be 50% or greater after 2.5 years, and can kill 40-100% of the susceptible olive cultivar trees. It has also been observed that higher initial inoculum densities lead to more disease. Any level above 1.0 microsclerotia per gram of soil is considered too risky for olives. Some *Verticillium* appeared in all of the Spanish test plots even at microsclerotia levels of 0.4/g of soil, but with inoculum levels below 1.0 microsclerotia per gram less than 15% of the trees showed disease symptoms after three years. In soils containing only the non-defoliating strain of *Verticillium* disease

Steps should be taken to prevent the introduction of *Verticillium* onto the ranch. Make sure no soil is brought onto the ranch from trucks or farm equipment. Do not intercrop olives with susceptible plant hosts. No weeds, especially broad leaves that harbor *Verticillium* should be allowed to grow in the orchard.

Inoculum levels can be reduced before planting by soil solarization, flooding the fields during summer, growing several seasons of grass or crucifer cover crops, fumigation, or a combination of these treatments. Soil solarization (elevated temperature) can reduce microsclerotia inoculum levels to almost undetectable levels within the top foot of soil. Several solarization experiments in Europe in existing *Verticillium* infected orchards stopped the progression of the disease for about three years. Soil flooding and crop rotation have also been shown to reduce inoculum levels. Incorporating a ryegrass or sudangrass cover crop or cruciferous residues such as broccoli has been shown to have an eradication effect on *Verticillium*. It may be that other organic soil amendments would have similar effects due to the development of antagonistic microorganisms or from inactivation from toxic volatile products released by the amendments. Soil fumigation with methyl bromide and chloropicrin, has been shown to reduce inoculum levels by 85-95%. Whether any of these practices are sufficient to make much of a difference is unknown, however. Dry farmed orchards in Europe where drip irrigation was added to improve production have suffered greater losses from *Verticillium* because the fungus proliferates in the wetted drip zone.

Cultivar resistance or the use of resistant rootstocks has been extensively studied as a way to potentially prevent losses from *Verticillium* wilt (See Table 1). There is no known rootstock that has been successfully used to protect trees. It appears that the fungus can move through the resistant rootstock into the susceptible cultivar, killing the top. Many varieties are quite resistant or immune to the non-defoliating strain, but most varieties are susceptible to the defoliating strain and none are immune to either strain. Only the varieties: Empeltre and Frantoio are very resistant. Observations in California for table varieties indicate that Ascolano is the most resistant, Sevillano is the most susceptible, and Manzanillo and Mission were intermediate. In Spain, in an experimental plot with 2.5 microsclerotia per gram of soil, 73-84% of the very susceptible and susceptible varieties were killed when the defoliating strain was present while only 8-20% of the trees of resistant varieties were killed. Those same varieties expressed disease levels of between 47 to 84%. When only the non-defoliating strain was present, 10 to 50% of the very susceptible and susceptible cultivars died and expressed disease levels of 20 to 73%. None of the resistant and very resistant cultivars were killed and most showed disease levels of 7 to 13%. It should also be noted that in several cases trees that showed initial *Verticillium* wilt symptoms (non-defoliating strain) later recovered from the disease.

Trials investigating soil or plant fungicidal sprays have been unsuccessful in controlling or preventing *Verticillium* wilt. Chemical control by means of tree trunk injection, however, with Dodine, Fosetyl-Al and Benomyl has been demonstrated to be successful in some cases and is currently under investigation in Europe. This may be a very useful tool in specific situations with high value trees.

LABS for VERTICILLIUM IDENTIFICATION

A sample of a branch that has both dead and live tissue can be sent to a plant pathology laboratory for identification. The plant tissue should be kept cool (about 50° F) in transit to the lab. Soil samples can also be evaluated for microsclerotia inoculum levels.

- Selected Private Labs Conducting Plant and Soil Disease Analysis
<http://ucce.ucdavis.edu/files/filelibrary/2161/32230.pdf>

Variety	Resistance Level
Aglandau	Resistant
Arbequina	Susceptible
Arbosana	Susceptible
Ascolano	Resistant
Blanqueta	Unknown
Bouteillan	Very Susceptible
Cayon	Unknown
Changlot Real	Resistant
Coratina	Susceptible
Cornicabra	Very Susceptible
Dolce Agogia	Resistant
Empeltre	Very Resistant
Frantoio/Oblonga	Very Resistant
Gordal Sevillana	Susceptible
Hijiblanca	Very Susceptible
Koroneiki	Resistant
Kalamon	Resistant
Leccino	Susceptible
Manzanilla	Susceptible
Maurino	Susceptible
Mission	Susceptible
Moraiolo	Resistant
Pendolino	Susceptible
Picholine	Susceptible
P. Marocain	Unknown
Picual	Very Susceptible
Picudo	Very Susceptible

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(*Verticillium*, Cont. on p.4)

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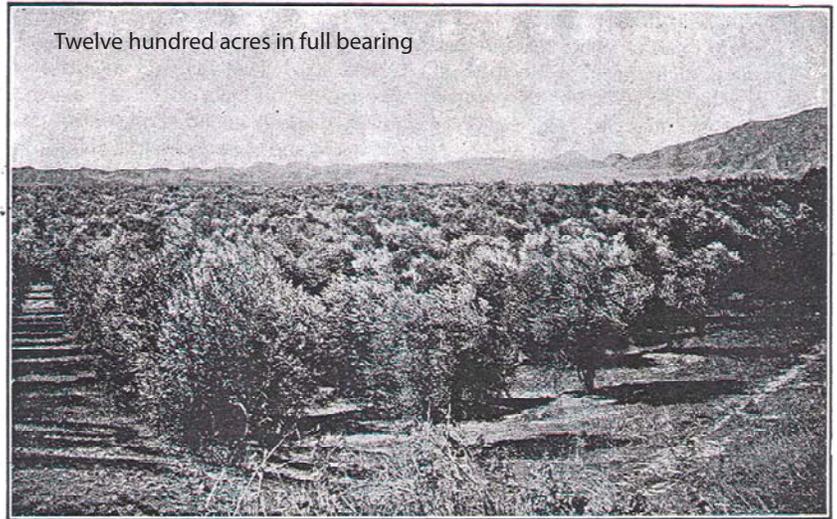
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A SEA OF TREES THE STORY OF SYLMAR, THE LARGEST OLIVE ORCHARD IN THE WORLD

By Bertha H. Smith

Sunset Magazine October 1907 (Reprinted with permission)

A Gray-Green stretch, beginning at the foot of a spur of the Sierra Madre foothills and ending, it would seem nowhere, but yonder to the skyline; sometimes motionless with clouds of fog resting drowsily on its undulating surface, sometimes swept by the wind into waves tipped with silver sun rays - this is Sylmar, sea of trees. Nowhere else in the world, is there anything quite like this vast sweep of olive trees, an orchard of twelve hundred acres in full bearing. The great prune orchards of Santa Clara valley in full bloom may surpass it in loveliness; but there is something awe-inspiring in the somber monotone and the boundless reach of this olive sea. From the railroad that for miles skirts the edge of the ranch the vista is down countless, endless aisles of trees, as in an orange grove or an orchard of prunes or pears or almonds. But the foothill side the straight lines are lost and tree tops merge in an unbroken surface rolling away to the horizon at the west and south. It is well named the Sea of Trees.



Sylmar has been a troubled sea on which for sixteen years the hopes of men have tossed restlessly. But that they were men with a great faith in California, a staunch confidence in themselves and in their purpose, their hopes much have been racked to pieces long ago. But to-day this is a smiling sea on which these hopes rock peacefully.

Sixteen years ago a company of Los Angeles men, Californians at heart if not by birth, bought a tract of two thousand acres to start an olive ranch. A thousand other men would have passed this land by, as they pass thousands of adjoining acres to-day, as fit only for the cactus, the sage-brush and mesquite that covered it. Perhaps these men justified their choice by the precedent of the padres who by a few miles away, at San Fernando Mission, had planted olive trees, a few of which after a century's time stand there to attest the virtues of the soil. Perhaps they had other means of knowing that this soil, pale with the mixture of sand and decomposed granite washed from the mountain side, was particularly adapted to the growth of olives, and that the drainage of this same mountain side would settle the question of irrigation.

Whatever the source of their faith, it was enough to last out the year it took to clear the land, at a cost of as high as fifty dollar for some of the acres. Then twelve hundred acres were set with trees from the same stock the padres planted more than a hundred years ago. And then these men went about their various other affairs until the trees should come into bearing, for they believed that if imported olive oil was worth from three to four dollars a gallon, a good California oil would bring five. Ten years later Sylmar produced its first real crop. Some of the original projectors, for this reason and that, had sold their interests. But always there were other men to take up the faith where these left off, and by the time the first crop was harvested nearly a half million dollars had been sunk in that sea of trees.

But now-thought the men who had waited ten years for the first crop that was more than enough for a few barrels of pickled olives-now it would no longer be all going out and nothing coming in. Those who had bought their interest later were joyous in the thought of a quick return on their investment. Ready for this first crop was a factory, as modern in plan and equipment as money could make it, and within sixty days after the olives ripened on the trees the great glass-lined tanks in the floor for the factory building held a quarter of a million dollars worth of the purest olive oil that could be made.

The makers of it believed absolutely that it was the best oil on the market. They did claim it purer than other California olive oil, for they concede to their California competitors an unadulterated article; but they did claim that it was not only of finer flavor but of purer quality than the imported oil, which until within the past two years was held to no particular standard of purity either by the inspectors or by the law. The improved facilities for making could not offset the cost of labor in California - two dollars a day for a man doing the work for which in Italy or France or Spain he would be paid ten cents - and it was necessary to place the price of this product above that of the imported article. But their faith in the quality of their product permitted them to do this without hesitation.

Twenty-five salesmen were sent out over the country to sell this first seasons output. They were the best salesmen that could be hired, and -not one man of the twenty-five sold enough olive oil to pay traveling expenses. Not satisfied with their efforts the manager of the company went to Chicago and New York, and these are his words:

"I begged men, I tell you, I begged them, to take our oil delivered in New York at a dollar a gallon, when other oil was bringing from one and a half to two, and they would not take it.

"I went to the buyer of the best-known hotel in New York, became well acquainted with him, and asked him if he would let us send him some of our oil. He sampled it, found no fault with it, and said: 'If I put your oil into this hotel, what is there in it for me?' To which I replied: 'There's nothing in it for you.' He did not buy.

(Trees, Cont. on p. 6)

(Trees, Cont. from p.5)

"I went to the manufacturers of the best-known brand of salad dressing and offered them our oil and was told they would accept it as a gift. I afterward learned that they were using fifty per cent of cotton-seed oil in the salad dressing and they had to keep up a big bluff.

"I went to the best-known manufacturer of pickles and asked him if he was in the market for olive oil. He told me he was always in the market for anything he used. In reply to my question as to whether he knew anything about our oil, he said: 'I don't know anything about it and don't want to know anything about it. We use two or three thousands gallons a year, but we don't want any California oil!' He did consent finally to take a small quantity at \$1.25 a gallon, delivered at the factory, and a year and a half afterward, when it didn't mean anything to us, he wrote for more.

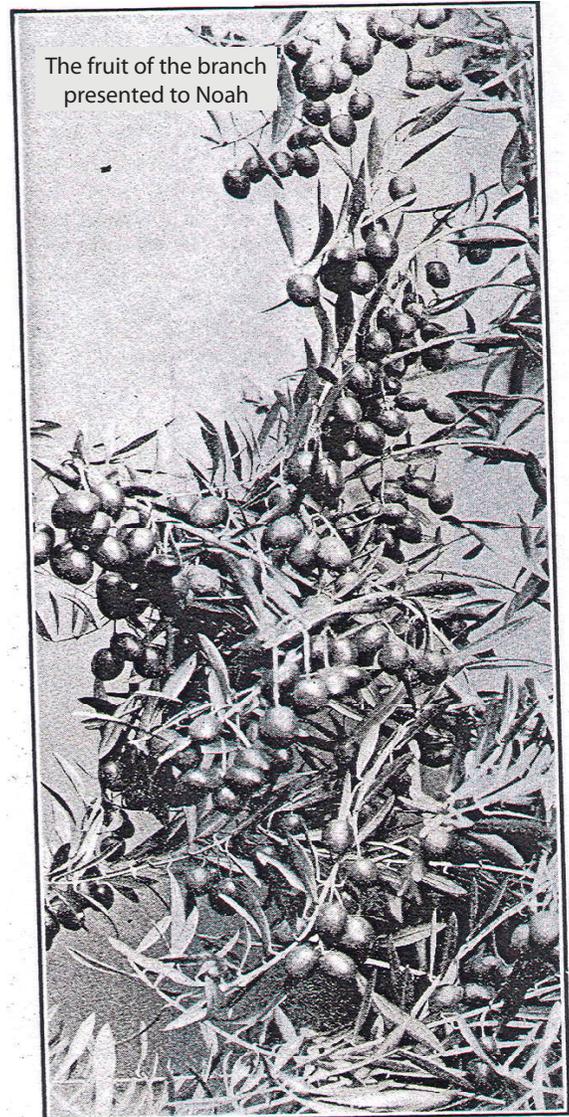
"I had started out to deal with jobbers, and on the way home I visited the leading jobbers in various large cities, and afterward wrote to those I had not seen. If I had this reply from one, I had it from a thousand:

"What do you suppose we want to handle your product for?
You have no market. When you get a market, come around!"

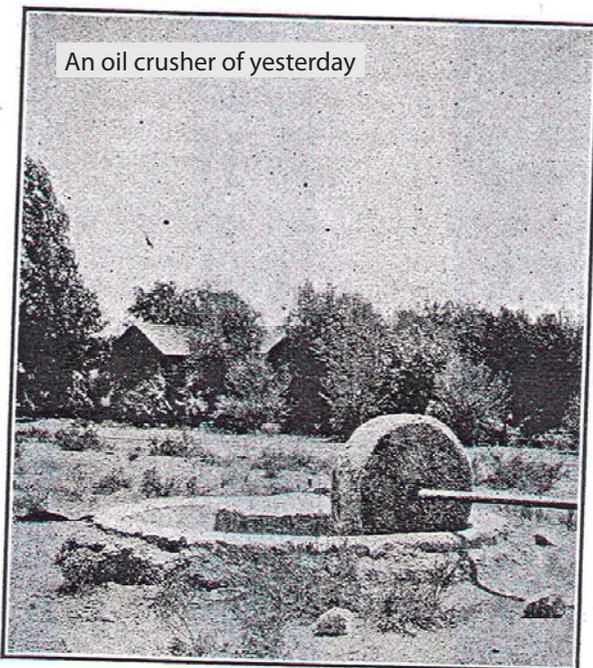
And so this manager came home convinced that if they wanted to get rid of the hundred thousand gallons of olive oil in their vats they would have to adopt other tactics. At this time the Sea of Trees seemed to have an ebb tide only, and it put to the test the courage and conviction of its owners.

Oddly enough, this was the psychological moment at which an offer came for a lease of the entire two thousand acres. The crude oil excitement was at its height in Southern California, and one of the big oil companies of Los Angeles coveted this particular piece of land. Its owners, their ardor perhaps a trifle cooled by the season's experience, gladly leased the property and from the slough of disappointment they were borne suddenly to the crest of the crude oil excitement. If Sylmar would not yield them wealth in its olive oil, perhaps it would in crude oil, and for the time being each man saw himself a millionaire.

But this bubble, too, soon burst. The first well sunk gave no indication of oil, and the men again set their hopes afloat on the Sea of Trees. This time, instead of seeking to convince the jobbers of the merit of their goods, they determined to convert the consumers.



The fruit of the branch presented to Noah



An oil crusher of yesterday

They advertised in the leading magazines and many newspapers. They bottled gallons of oil in small bottles and distributed samples free to everybody that wanted them and to many that didn't. They offered to prepay express on orders received from any part of the United States. By and by orders came for a bottle or two, or a gallon, sometimes accompanied by a money order, sometimes on the conditions offered, that the money need not be paid until the oil was sampled and found satisfactory. These orders were filled with the nicest care, and the buyer was asked to write his opinion. If it was evidently a housekeeper, she was asked in case she liked the oil to tell her neighbors about it. Always they believed absolutely that the person who once used their oil would never use any other.

When they had secured two or three orders from one town, they would take one of the big business directories and pick out two or three grocers in that town and write them that these people were sending to the factory for the oil-would it not be to their interest to put it in stock and supply these and other possible customers? About seventy-five per cent of such letters resulted in an order for a case of quarts. If the housekeeper ordered again she would be told she could get the oil from her home grocer. Perhaps she would insist that she preferred to get it from the factory, knowing it would always be the same. If so, it was shipped from the factory, through the grocer, who was credited with her remittance and the express charges.

While thousands and thousands of cases were being sold in this way, the company again made a test of the jobbers. A hundred pint bottles were mailed to the leading

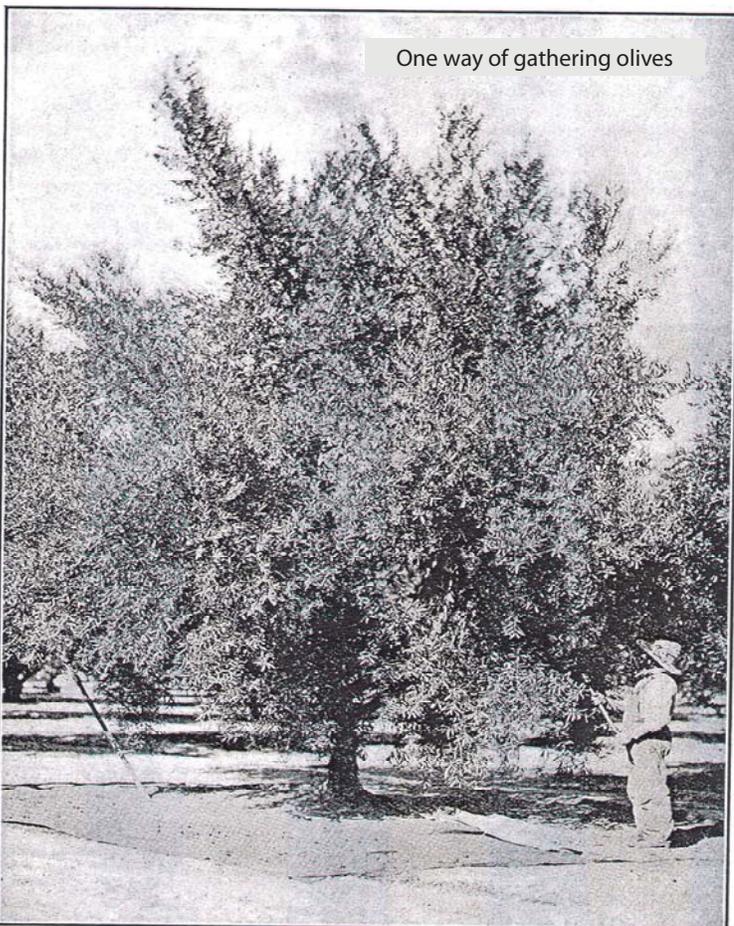
(Trees, Cont. to p. 7)

(Cont. from p. 6)

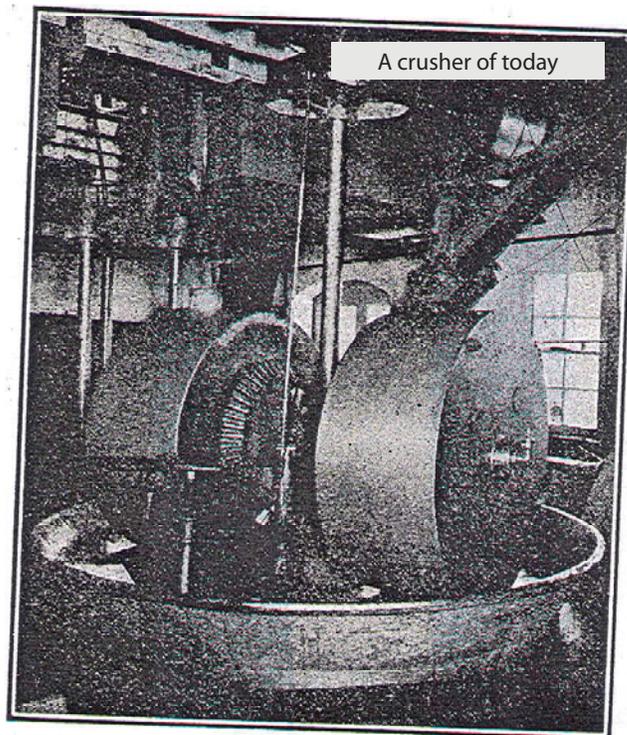
jobbers of the East. There was just one acknowledgment and that was from a man who wrote that he did not buy olive oil.

While carrying on this advertising campaign, which cost something like \$75,000 the company was sparing no expense to improve the processing of their oil. They knew by experiments during the years when the trees were coming into bearing that the quality and flavor of the oil are different every year, and the vexing question with oil producers is how to keep their product up to a certain fixed standard. This is an advantage the big producer has over the little one. The small producer who runs his machinery by horse-power and whose press is as crude as that used fifty or a hundred years ago, gets as pure oil as the man whose machinery is operated by electricity and has a capacity of a thousand gallons or more a day. But to maintain a standard of quality and flavor, which depend upon the manner of pressing and acuteness in determining the exact conditions that arise from year to year, it is necessary to make a vast quantity and keep it in storage.

At Sylmar a French expert was hired at a fancy salary to find fault with the methods first employed, and he did it. Not with the methods of manufacture, but with the processing and the handling. These are not as simple as they look. Here the ripe olives are hauled to the door of the factory in the picking boxes. These are weighed and credited to the five-acre lot from which they come, and a record made that the superintendent may know what every five acres is doing, and whether it needs special attention to increase its yield. The olives are then fed into a machine that fans them clean and slightly bruises them ready for the great crusher. In this first crushing the liquid that comes off is three-fourths water and one-fourth oil. From the "cheese" the oil is expressed in the reverse proportion, and flows in a thick brown stream heavy with vegetable matter. In this crude state it is so full of tannic acid that it would eat through a sealed can.



One way of gathering olives



A crusher of today

The extraction of all foreign elements, the clarifying of the oil to a clear rich amber, the insuring of its keeping qualities under ordinary conditions—these are the secrets which the French expert confided to the superintendent at Sylmar. He did not attempt to eliminate the rich nutty flavor which distinguishes the California product from the smooth and almost tasteless oil of foreign manufacture which some people prefer to-day in spite of all efforts at education.

But while the French expert was applying his knowledge and experience to the new conditions of California, the campaign of education had been prosecuted vigorously, and gradually the ebb tide was turning toward the flood. With grim satisfaction the manager of the company recalled the invitation of those hundreds of jobbers, "When you get a market, come around." Remembering his rebuffs he declares that to-day he would not walk into any store in the United States to offer his goods. He does not have to. It is the jobbers themselves that come around. He did as they bade him and got his market and they have no choice but to order his product. Orders have increased to such an extent that the present capacity is inadequate. Before another season the size of the plant will be doubled, giving it a capacity of twenty-five hundred gallons a day.

Not a small point in the general triumph is the constant refusal of requests from large jobbers to put up this olive oil under private brands. Not a bottle nor a can ever leaves the factory except under the Sylmar label, save as the oil is shipped in drums to the company's bottling works in Vermont where the necessary glass can be secured within two hundred miles. The freight thus saved on the product for Eastern distribution is a considerable item.

The olive season is a short one. The fruit ripens in January and within thirty days from the time the five hundred Japanese pickers descend upon the orchards the entire crop is in. At the end of sixty days the oil-making season is over. The tons of pumice carry twelve per cent of oil, and these go again through the press, and the oil extracted being used for lubricating purposes. Experiments are

(Trees, Cont. to p.8)

UPCOMING EDUCATIONAL EVENTS

- Sensory Evaluation Short Course, April 3rd and 4th, 2009

Olive Fly Stings

Here is a photo of classic olive fly stings in fruit that just started showing up the week of August 15th on the North Coast. Usually the fruit must be about 2/3 size before the flies will lay eggs into it. The ovipositor of the female fly usually goes in at an angle and leaves a darkened line in the fruit flesh.



UC Davis Appoints Olive Center Advisory Committee

Tom Burchell	Mark Linder
Alexandra Devarenne	Mike Madison
Greg Drescher	Felix Musco
Ann Evans	Dick Nielsen
Dr. Louise Ferguson	Dr. Vito S. Polito
Dr. Jean-Xavier Guinard	Dr. Charles F. Shoemaker
Kate Hart	Ed Stolman
Dr. Clare M. Hasler	Dan Vecere
Adin Hester	Paul Vossen
Alan Greene	Brady Whitlow

(Trees, Cont. from p. 7)

now being made looking to the manufacture of castile soap from the oil still contained in the residue.

On account of the location of the Sylmar orchards there is a full crop but once in two years. In the off year the crop is but about one-fifth that of a full year. To tide over the lean year the several hundred unused acres of the Sylmar ranch are being put under cultivation. Last year two hundred acres were set to Flaming Tokay grapes. This season some more hundreds of acres are set apart for a nursery with a start of nearly a half million trees. In these new ventures the basis of the owners' faith is a fast belief that there is something in a name.

And this is why they can say with a smile that Sylmar has never yet paid a dividend. These improvements represent the nice profits of two seasons since the jobbers of the country were whipped into line on the product of this ranch, and its owners are content, for to-day Sylmar is a smiling sea.

(Oil Crop Cont. from p. 1)

CA OLIVE OIL GROWERS AND ACREAGE				
Region	2004		2008 Estimated	
	Growers	Acreage	Growers	Acreage
North Coast	268	1,535	300	1,950
Central Coast	59	376	70	600
So. Coast & So. Cal.	17	70	25	150
Sacramento Valley	94	3,216	120	9,600
San Joaquine Valley	39	707	65	7,500
Sierra Foothills	51	264	80	550
TOTAL	528	6,168	660	20,350

2004 data based on UC survey by P. Vossen and A. Devarenne.
2008 data based on estimates by P. Vossen



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