significant results. Nevertheless, since tydeids are important as alternate prey for *M. occidentalis* throughout the valley, covercropping practices which encourage wind-blown pollen might be beneficial.

The covercropping studies revealed predation on spider mites from an unexpected source. Upon maturing and drying of the Cucamonga and Blando brome covercrops in late spring (early June), western flower thrips (*Frankliniella occidentalis*) was observed to move onto grapevines in large numbers and feed upon Pacific mite eggs. Laboratory observations indicate that this plant feeding insect may also develop on spider mite eggs. Usually, western flower thrips is thought of as a pest of agricultural crops, including certain varieties of table grapes. Perhaps this sort of general predation is an important facet of natural control in complex environments. Certain covercropping practices may help simulate such conditions.

Finally, the studies have shown that Pacific mites may be kept under control in grapevines in western Fresno County vineyards by irrigation with overhead sprinklers. Table 4 summarizes the 1969 trial results. Similar results were obtained in 1968 and 1970. Pacific mites are suppressed by the washing and drowning action of sprinklers. However, populations of *M. occidentalis* were little affected by overhead sprinklers. Laboratory studies revealed that Pacific mites quickly drown when submerged in water, while *M. occidentalis* can withstand prolonged submergence.

The tests indicated that more frequent than usual sprinkler application for irrigation may be needed. For example, it was necessary to sprinkle approximately every 10 days during late June and July to keep the Pacific mite in check. Also, sprinkling should be discontinued in Thompson seedless by the end of July or early August to prevent berry cracking. Normally, raisin growers do not irrigate later than July, so this should present no great problem.

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Effects of urbe alteration of f and mangane MUSTARD

A YELLOWING OF LEAF MARGINS appeared in the summer of 1970 on mustard plants grown commercially on Bay Farm Island in Alameda County. The symptoms had a drastic effect on the saleability of the crop, and the yields were reduced by almost half.

Several clues to the problem were provided by the grower. In the past he had used manure fertilizers with great success. As housing tracts closed in on the farming area, municipal authorities forced him to abandon the use of manure because of disagreeable odors and the influx of flies to the newly developed community. Instead of manure, ammonium sulfate and phosphate became the chief source of fertilization.

A test of the soil reaction with a pH meter revealed a pH slightly below 5. This suggested a possible acid toxicity. In addition, the yellow leaf borders strongly resembled the symptoms found on lettuce plants grown on acid soils. The use of ammonium fertilizers also pointed in the direction of an acidity problem. A hypothesis was formed that the symptoms were induced by excess manganese as a result of the use of physiologically acid fertilizers.

Analysis of the plants showed high concentrations of manganese in the leaves, especially in the margins where the yellow color appeared.

It was recommended that the grower add 2 tons of dolomite per acre, while greenhouse tests were initiated to test the hypothesis. Soils from the field were placed in pots and treated with the physiologically acid fertilizers ammonium

TABLE 1. EFFECT OF LIME ON SOIL pH AND MUSTARD YIELD USING DIFFERENT NITROGEN FERTILIZERS

Fertilizer treatment	Soil pH		Yield (dry weight)	
	+lime	−lime	+lime	−lime
	pH		grams	
$Ca(NO_3)_2$	6.2	5.3	3.03	2.31
NH_4NO_3	5.5	4.9	3.13	2.82
$(NH_4)_2SO_4$	4.8	4.3	2.73	2.06

nitrate and sulfate, and the physiologically basic fertilizer calcium nitrate. Half the pots were treated with dolomitic lime. The pots were seeded to mustard and placed in the greenhouse. Following a month of growth the plants were harvested and pH values were obtained for the soils (table 1).

In the absence of lime, yellow margins developed on the leaves of all plants, the severity of the symptoms increasing directly with acidity. Where lime was added, only the ammonium sulfate treatment showed any visible chlorosis.

The island soil is a light textured loamy sand, low in organic matter with a weak buffering capacity which allows the pH to shift rapidly with nutrient uptake by the plants. With a higher organic matter content the soil would be able to maintain a more stable pH.

Within three months of the time lime was applied to the soil, the disease was completely eliminated and the pH of the soil had risen to values near the neutral mark. Analysis of leaf tissue from plants grown in the field showed a marked decrease in manganese in all leaf parts of plants from the area where the soil had been limed (graph 1). The figure shows

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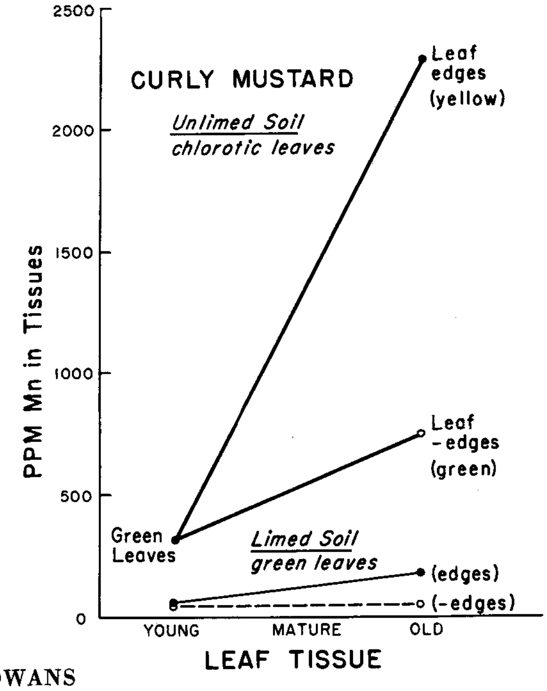
GRAPH 1. EFFECT OF LIME ON Mn CONTENT OF MUSTARD LEAF TISSUE.



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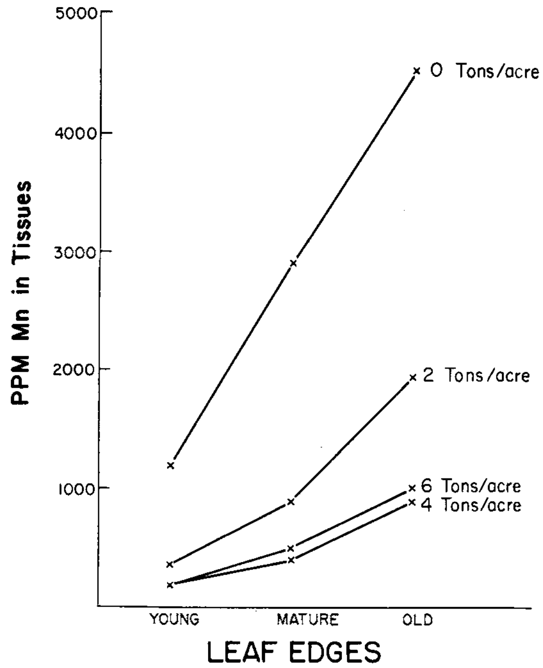
Healthy green leaves and increased growth of curly mustard plants (photos above) growing on Alameda's Bay Farm Island after liming, contrast sharply with typical yellow leaf margins and lower production of untreated plants (lower photos).


data obtained from tissue samples of plants grown before and after the soil was limed. Leaves of plants grown prior to liming had a manganese content of approximately 2,300 ppm in the yellow margins of the affected leaves and 750 ppm in the green portion of the leaves.

GRAPH 2. EFFECT OF LIME RATES ON Mn CONTENT OF MUSTARD LEAF TISSUE IN THE PRESENCE OF $(NH_4)_2SO_4$ FERTILIZER.



GRAPH 3. EFFECT OF FERTILIZERS AND LIME ON Mn CONTENT OF MUSTARD LEAF TISSUE.

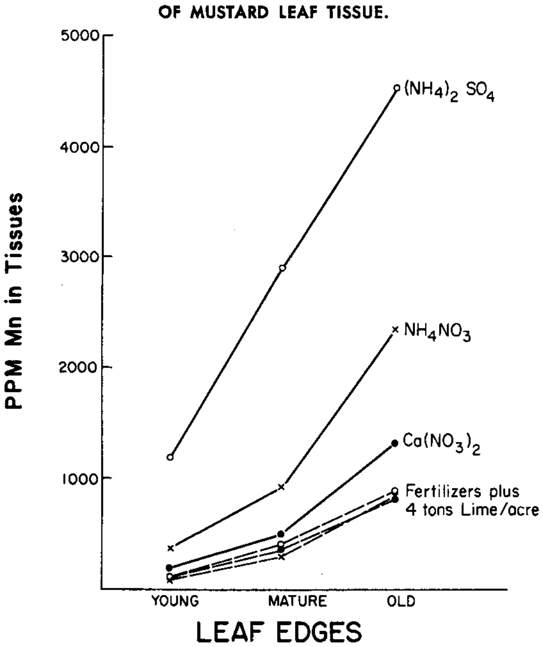


TABLE 2. EFFECT OF NITROGEN FERTILIZERS AND LIME TREATMENTS ON SYMPTOMS OBSERVED ON THE OLD LEAVES OF MUSTARD PLANTS*

Tons of lime	$(NH_4)_2SO_4$	NH_4NO_3	$Ca(NO_3)_2$
0	Moderate to severe yellow and necrotic borders	Trace yellow and necrotic borders	Trace yellow and necrotic borders
2	Slight to trace yellow and necrotic borders	No symptoms	No symptoms
4	No symptoms	No symptoms	No symptoms
6	No symptoms	No symptoms	No symptoms

* Similar symptoms were observed on mature and young leaves but with a marked reduction in severity.

Similar data were obtained for China as well as Curly mustard. Leaves from plants grown on the soil after liming showed a marked reduction in manganese content. These plants were separated into young, mature and old leaves. In each case a one-half inch wide margin or edge was trimmed from the leaves, and the edges and remainder of the leaf were analyzed separately. In all cases the leaf edge contained slightly more manganese than did the rest of the leaf material. The greatest amount of manganese was found in the older leaves. In no case did the manganese content of the plants from the limed plots exceed 200 ppm. In the case of the China mustard from the limed plots there was little difference between the manganese content of the leaf edges and that of the remainder of the leaf from which the edges had been removed. In each case manganese values were below 100 ppm. The soil in this case was slightly more alkaline than the soil where the Curly mustard was grown.

The photos taken in the field show the elimination of the disease and the increased growth which resulted from the liming treatments. Yield was increased over 50 per cent by the addition of lime and the saleability increased markedly by the prevention of yellow margins.

In a second experiment, the amount of dolomitic lime added to the soil was varied at 0, 2, 4, and 6 tons per acre. Each rate was added to pots previously fertilized with 300 lbs of nitrogen per acre in the forms of $(NH_4)_2SO_4$, NH_4NO_3, and $Ca(NO_3)_2$. The plants were grown for a period of 39 days and then harvested, separated into four fractions, oven dried, weighed and analyzed for their manganese content. A margin approximately one-half inch wide was cut from the entire edge of each leaf and the leaf margins were analyzed separately from the rest of the leaves. Since the yellowing occurs at the leaf edge, data is presented for only this part of the plant, although similar trends, with much lower manganese values, were observed for leaves minus edges and for petioles. Graph 2 shows the effect of lime rates on the manganese content of leaf edges for young, mature, and old leaves where $(NH_4)_2SO_4$ has been used as a fertilizer. It was quite obvious that the older tissues contain the most manganese, and that the addition of lime causes a marked decrease in manganese uptake by the plants.

TABLE 3. MUSTARD YIELD AS A FUNCTION OF FERTILIZER AND AMOUNT OF LIME*

Tons of lime	Yield/plant in grams dry weight		
	$(NH_4)_2SO_4$	NH_4NO_3	$Ca(NO_3)_2$
0	1.82	2.68	2.40
2	2.63	3.15	3.02
4	2.40	2.90	2.90
6	2.51	2.80	3.06
Average lime treatment	2.51	2.95	3.00

* Thirty-nine days growth.

The effect of type of nitrogen fertilizer on manganese content of leaf edges is shown in graph 3. These data are in agreement with the data in table 1. The manganese content is found to be the highest where the acidic $(NH_4)_2SO_4$ fertilizer was used and less where the neutral or alkaline fertilizers were used. Addition of 4 tons of lime per acre markedly reduced the manganese content of plants at all nitrogen treatment levels.

Symptoms observed on the old leaves are listed in table 2. These varied from moderate to severe yellowing, and necrosis of the leaf borders (in the $(NH_4)_2SO_4$ treatment), to trace symptoms in the $Ca(NO_3)_2$ treatment. Where lime was added at the 2-ton rate there were a few trace symptoms in the old tissue of the $(NH_4)_2SO_4$ treatment, but none at higher lime rates. Only trace symptoms were observed in the NH_4NO_3 and $Ca(NO_3)_2$ treatments in the absence of lime, and there were no symptoms in the presence of lime.

Yield values for the various treatments are shown in table 3. Yields are lowest where the manganese symptoms were most severe and where the manganese content of the tissue was high. However, liming or use of neutral or alkaline fertilizers caused an increase in yield. Addition of 4 to 6 tons of lime per acre gave no increase in yield over the 2-ton rate. Addition of lime increased yields over check plots, and with the increase in pH, the manganese content of the plant and symptoms decreased.

These results indicate that urban as well as rural farmers and gardeners should be aware of problems which can arise as a result of reactions between soils and plants and the various materials added to improve the soil for plant growth.

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