punched for electronic data processing under the direction of W. O. Gauer, Environmental Toxicology, Davis.

The California Department of Food and Agriculture provided copies of computerized data from the state-wide Agricultural and Restricted Chemicals Use Reports it has collected since 1970. By 1974, the Food Protection and Toxicology Center data bank contained pesticide use records for all 58 California counties for the four-year period 1970 through 1973, plus records of pesticide use in Fresno County for 1968 and 1969. The data, stored on 45 reels of computer tape, detail more than 2 million applications of over 600 million pounds of chemicals on 135 million acres.

Each use report includes the formulation used, quantity applied, method of application (air, ground, other), commodity treated, location of use (county, township, and section), date of application, acres treated, purpose of usage (agricultural, structural, vector control, state highway, etc.), and applicator. Identification of the pests involved has been unreliable, and is no longer entered into the computerized records. The use reports are subject to certain limitations and errors, such as inaccurate or incomplete entries by applicator and errors in coding or key-punching. California Department of Agriculture personnel, who estimate 2 to 5 per cent errors, make corrections when possible. In addition, we have been able to identify and correct some errors through our verification and analytical procedures. The data on usage are incomplete, in that reports are not required for non-restricted chemicals applied by farmers on their own or neighbors' property, for pesticides applied to federal lands by federal operators, or for small quantities of pesticides sold for use by home owners or home gardeners. Despite these limitations, the registration and reporting system used in California since 1970 provides the only detailed records presently available documenting pesticide usage for the state, over a five year period.

Information on pesticides applied and commodities treated can be retrieved in many forms, including tabulations, summaries, graphs, and maps. Data can be retrieved for any area that can be located by township(s), range(s), and section within a county. The maps are prepared by using a Cal-Comp Plotter in conjunction with the computerized data. For example, figures 1 and 2 map where and how much parathion (figure 1) and toxaphene (figure 2) were reported applied in Fresno County in 1972. They show that parathion was used extensively in the central part of the county, whereas toxaphene was used primarily in the western section. Figure 3 illustrates another map which indicates every section where any chemical was reported applied to cotton acreage in 1972. Cotton acreage is treated with many types of pesticides, including insecticides, herbicides, and defoliants; the map consequently also shows where cotton was grown in Fresno County in 1972.

Graphs of yearly and monthly use of pesticides are aids in planning the timing for experiments requiring air and soil sampling in the field. For Fresno County the peak period of use of carbaryl (a carbamate insecticide) has been June, July, and August each year (figure 4). The graph also shows the increased use of carbaryl in 1973. The use of paraquat (a herbicide) has also increased steadily, with two peak periods of use (figure 5).

Figure 6, an example of information retrieved in tabular form, lists the major organophosphate insecticides used within a three-mile radius around one section in Kings County in 1973. A similar study was done for four agricultural valleys in southern California, each of which covered several townships.

Use of registered or trade names of pesticides is for identification only and does not constitute a recommendation.

FIG. 6. ORGANO-PHOSPHATE AND CARBAMATE INSECTICIDES APPLIED IN A 3-MILE RADIUS AROUND A DAIRY IN KINGS COUNTY IN 1973.

Insecticide	Pounds
Azodrin	281.41
Diazinon	481.75
Dimethoate	206.55
Imidan	693.00
Malathion	772.51
Methyl Parathion + Rel.	222.04
Naled + Rel. Naled	584.74
Parathion + Rel. Parathion	630.48
Phorate	1522.03
Systox	129.87
Disyston	333.07
Metasystox	25.98
Carbofuran	47.74
Temik	38.20
Methomyl	97.75

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PLANTS IN CALIFORNIA tree nurseries frequently display nutrient deficiency symptoms where methyl bromide is used as a preplant fumigant. These nutrient deficiencies—mainly zinc but sometimes phosphorus—cause poor plant growth and stunting. Part or all of certain nursery fields are sometimes lost because trees fail to reach minimum salable size.

Pot-culture experiments with peach seedlings have confirmed that plant nutrient problems are associated with methyl bromide-fumigated soils. Mixing both phosphorus and zinc with fumigated soil greatly improved growth in these experiments. The standard practice in most nurseries is to side-dress phosphoric acid and zinc chelate into the seedbed rows at planting time. This practice results in improved growth, but it does not completely solve all the nutritional problems. Zinc deficiency and stunted growth may still occur in young seedlings.

Other research has shown that certain strains of mycorrhizal fungi placed in methyl bromide-sterilized soil enhanced the ability of the seedlings to overcome nutrient deficiencies. It was also found that peach seedlings grown in methyl bromide-fumigated soils were devoid of mycorrhizal fungi, which are killed by the fumigant.

Mycorrhizal fungi live in a symbiotic relationship with plant roots. Studies have shown that this association can aid the plant by increasing water and nutrient uptake, while the fungus benefits from the increased availability of nutrients. In nature the roots of cultivated and noncultivated plants are commonly infected with mycorrhizal fungi. One type, the vesicular-arbuscular (VA) mycorrhizae, occurs on more plant species than any other type and is present in many agricultural crops.

An experiment was conducted in a commercial nursery to test the merit of the symbiotic relationship. The field (Foster fine sandy loam) was fumigated with 360 pounds of methyl bromide per acre in the early fall of 1973, using the standard technique of fumigant injection followed immediately by polyethylene tarping. Peach seed (Red-leaf Lovell) was planted in November 1973. Treatments were: (1) fertilization with phosphorus and zinc; (2) phosphorus and zinc fertilization plus inoculation of VA mycorrhizal fungi; and (3) inoculation with VA mycorrhizal fungi, but no fertilization with phosphorus and zinc. There was also an untreated check plot. The experimental design was a randomized

Mycorrhizal fungi and peach nursery nutrition

J. H. LA RUE · W. D. MC CLELLAN · W. L. PEACOCK

This trial shows that mycorrhizal fungi helps peach seedlings extract zinc from the soil. The fungi were equally or more effective in overcoming soil-fumigation nutrient-deficiency effects in peach nursery seedlings than the standard nursery practice of side-dressing phosphorus and zinc at planting time. Further studies are under way to determine application and placement methods which show the greatest inoculation efficiency in peach and other plant species.

complete block with four treatments and four replications. Each plot consisted of 38 feet of row containing 35 to 40 peach seeds.

The phosphorus and zinc combination was placed six inches deep and seven to eight inches on each side of the row in November 1973 and consisted of 200 pounds per acre of 52% phosphoric acid and two gallons per acre zinc chelate (6.5% metallic zinc). The VA mycorrhizal inoculum was an isolate of *Glomus fasciculatus* that originated from Thermal, California, and was supplied by Dr. J. W. Gerdemann, University of Illinois. This isolate was propagated on sudangrass roots in pot culture. The inoculum consisted of soil and roots of the pot cultures, which were mixed thoroughly before transfer to the field. Approximately five grams of the inoculum was placed four to six inches below each seed on December 20, 1973.

Results

All seedling leaves in the experiment appeared zinc deficient until June 1974. Subsequent new growth in mycorrhizal-inoculated seedlings showed no zinc deficiency symptoms. By July, untreated seedlings were still stunted and zinc deficient; those treated with phosphorus and zinc showed moderate zinc deficiency, but growth was not retarded as severely as in unfertilized trees. Both treatments inoculated with VA mycorrhizal fungi were growing vigorously and showed no nutrient deficiency. By the end of the growing season, both height and trunk diameter measurements showed a significant increase in growth brought about by the presence of either VA mycorrhizal fungi or phosphorus and zinc fertilizer as compared to the untreated check.

Leaf samples were taken for nutrient analysis in early October 1974 (see table). The VA mycorrhizal-inoculated plants had significantly higher levels of zinc than did noninoculated plants. Phosphorus and potassium levels were similar in all treatments; nitrogen and manganese concentrations were significantly higher in the untreated areas.

Roots taken from each treatment in November 1974 were cleared, stained, and examined for the presence of VA mycorrhizae. Only roots from VA mycorrhizal-inoculated treatments showed clear evidence of the fungus, *Glomus fasciculatus* (see photo).

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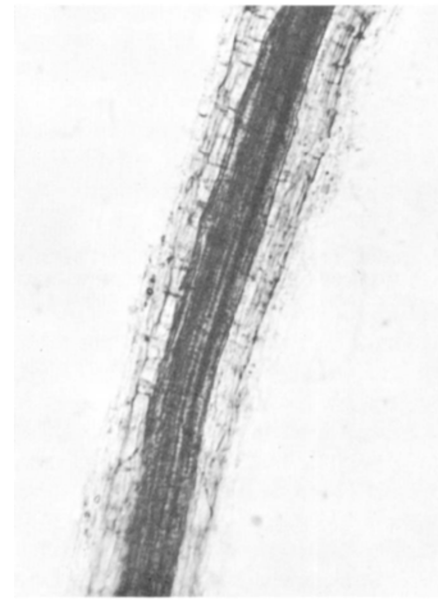

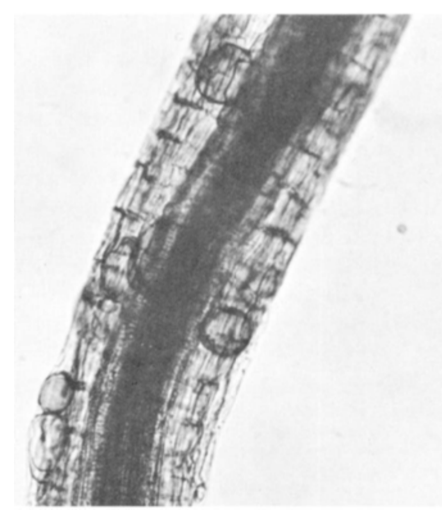

Red leaf Lovell peach roots: (above) from untreated control and (below) from mycorrhizal inoculated treatment showing prominent vesicles characteristic of vesicular-arbuscular types of mycorrhizae.

TABLE 1. THE EFFECT OF MYCORRHIZAL FUNGI AND FERTILIZATION ON THE GROWTH OF PEACH SEEDLINGS PLANTED IN METHYL BROMIDE FUMIGATED NURSERY SOIL*

Treatment	Growth measurements Average trunk diameter (mm)	Average height (m)
Untreated	10.40 a	1.35 a
Fertilization alone	21.94 b	1.93 b
Fertilization + mycorrhizae	24.11 b	2.24 bc
Mycorrhizae alone	26.30 b	2.42 c

* Means followed by the same letter(s) are not different at the 5% level of probability.

TABLE 2. THE EFFECT OF MYCORRHIZAL FUNGI AND FERTILIZATION ON NUTRIENT LEVELS OF PEACH SEEDLINGS PLANTED IN METHYL BROMIDE FUMIGATED NURSERY SOIL*

Treatment	Results of Leaf Analysis % N	% P	% K	Mn (ppm)	Zn (ppm)
Untreated	4.38 a	0.13	1.70	64 a	10.7 a
Fertilization alone	3.42 b	0.13	1.75	29 b	12.6 a
Fertilization + Mycorrhizae	2.99 b	0.15	1.79	24 b	16.8 b
Mycorrhizae alone	2.99 b	0.16 (NS)	1.80 (NS)	25 b	18.9 b

* Means followed by the same letter(s) are not different at the 5% level of probability.