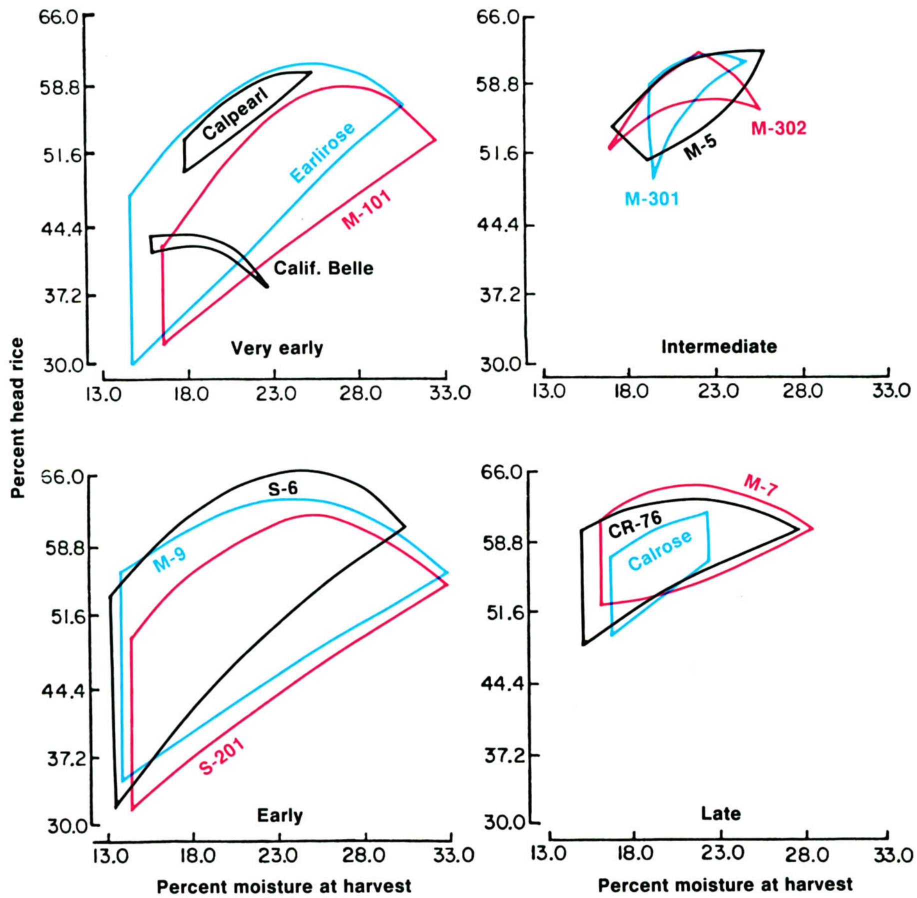

Rice cultivar responses to moisture content at harvest. Head rice (milling quality) increased in variability and decreased in amount at lower moisture contents, particularly among early and very early varieties. Late and intermediate cultivars generally showed higher and more stable head rice.

Acreage during the 1979-82 period markedly increased, placing a strain on management ability, resulting in delayed harvest and possibly improperly adjusted combines. Rice driers during this period were also burdened with a large crop and a high energy cost; they reacted by placing moisture limits and quotas on incoming rice, so that some rice was harvested below desirable moisture levels. Even though 70 percent of the rice in this study was harvested in the 20 to 25 percent range, the average harvest moisture content was 21.5 ± 2.5 percent. This is close to the low end of the critical range, and suggests that a substantial amount of California rice is being harvested too dry for maximum quality.

Harvest moisture content may also have indirect effects on milling quality. Rate of drying and cyclic water sorption and desorption caused by climatic conditions (dew, dry winds, sunlight) can cause kernel breakage and are associated with harvest moisture content. In other words, both how dry the grain is and how it got dry are important in the yield of head rice.

A preliminary analysis of the 1983 season indicated that the head rice percentage was higher that year than the average of the four years we studied. Reduced acreages, possibly higher moisture at harvest, less burden on dryer capacity, and favorable weather during the ripening period may have contributed to the increase.

Numerous environmental factors exist that, individually or collectively, can drastically affect head yield of a given lot of rice. In this analysis, cultivars varied in their response to moisture content at harvest, suggesting that sensitive cultivars such as M-101 and S-201 should be managed more closely to help alleviate this component of the quality problem.

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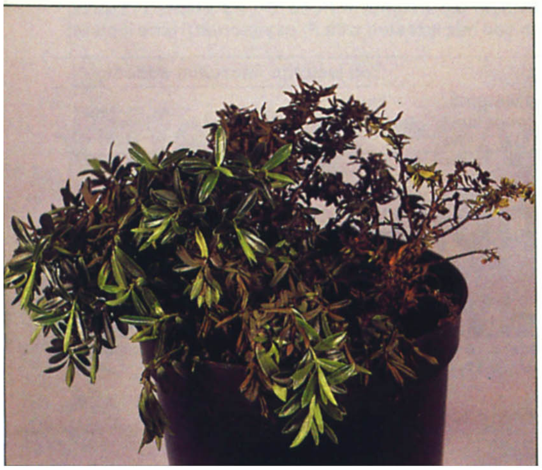
Veronicas (*Hebe* spp.) are widely grown in California for their evergreen foliage and bright, persistent white and lavendar blooms.

Fertilizer Fusarium

Diseases caused by the fungus *Fusarium oxysporum* have long been a major problem in growing agricultural and horticultural crops. By means of thick-walled resting spores, the organism can survive in the soil for years without a living host as a food source. Because of the high cost of fumigation and the possibility that the fungus may be reintroduced, genetically resistant host plant lines have offered the most effective means of dealing with these diseases. Greenhouse studies, however, have demonstrated that the landscape shrub *Hebe buxifolia* and related cultivars that are extremely susceptible to a strain of *F. oxysporum* may be successfully grown in the presence of this pathogen through the use of certain fertilizer combinations.

Fusarium wilt of *Hebe*

Species and hybrids of the genus *Hebe*, commonly called veronicas, are



Plants affected by ***Fusarium oxysporum*** **show uneven die-back of foliage, particularly in warm weather. Entire plant may die.**

A new *Hebe* 'Coed' plant grown in a container and fertilized with calcium nitrate, phosphorus, and potassium chloride (left) was protected from Fusarium wilt, even when planted in infested soil. Plant at right, on ammonium sulfate program, shows disease symptoms.

helps control wilt of *Hebe*

Randolph Keim □ Wesley A. Humphrey

The treatment reduces disease severity but doesn't eliminate it

widely grown in California for their evergreen foliage and bright, persistent, white and lavendar blooms. In 1957, Dr. R.D. Raabe, University of California, Berkeley, identified *F. oxysporum* as the cause of a serious vascular wilt of this genus of plants. No major spread of the disease occurred at that time.

Recently, however, the disease has appeared in several southern California production nurseries on *H. buxifolia, H. elliptica* 'Variegata', and hybrids *Hebe* 'Blue Elf' and *Hebe* 'Co-ed'. Tissue isolations and subsequent artificial inoculations proved that the causal organism was a strain of *F. oxysporum.* Fungicides have not been effective against this organism.

Affected plants show an unbalanced die-out of the foliage with some defoliation, particularly during warm weather. Leaves may be in various stages of decline, appearing dry and wilted or having a dark brown discoloration working outward from the petiole. Eventually, the leaves become completely discolored, collapse, and fall. Seriously diseased plants usually die.

In diagnosis of this disorder, it is helpful to examine stems of affected plants for browning of the vascular system (internal conducting tissues) and to compare them with tissues of a healthy stem. This symptom often may be discovered on suspect plants that do not yet show outward signs of the disease. Since another disease also causes internal browning of *Hebe buxifolia,* however, only culturing can given an accurate final diagnosis.

Internal stem tissue of plant affected by *Fusarium oxysporum* fungus may turn brown before outward signs of disease appear (upper photo). Stem tissue of the plant at right is healthy.

TABLE 1. Presence or absence of Fusarium wilt in Hebe 'Co-ed' plants under different fertilizer/fungicide treatments

		Inoculum added		
Fertilizer treatment*	No inoculum	No fungicide	Benomyl†	Imazalil‡
Calcium nitrate plus phosphorus plus potassium chloride	No disease	15 healthy 1 diseased	16 healthy —	15 healthy 1 diseased
Ammonium sulfate plus phosphorus	No disease	— 16 diseased	5 healthy 11 diseased	1 healthy 15 diseased

NOTE: 16 plants per treatment

*Nitrogen at 200 ppm; phosphorus at 46 ppm; potassium at 444 ppm; chloride at 400 ppm, continuous feed.

†Benomyl at 600 ppm, 200 ml per pot every 14 days, four applications.

‡Imazalil at 300 ppm, 200 ml per pot every 14 days, four applications.

TABLE 2. Fresh individual top weights of *Hebe* 'Co-ed' plants 112 days after being planted in soil mix infested with *F. oxysporum* (Hebe isolate)

		Top weights, inoculum added*		
Fertilizer treatment	Top weights, no inoculum*	No fungicide	Benomyl	Imazalil
	Grams			
Calcium nitrate, phosphorus, potassium chloride	107.3 a	101.5 a	110.8 a	102.6 a
Ammonium sulfate, phosphorus	115.1 a	26.2 c	70.8 b	42.4 bc

* Each weight is the average of 16 individual plants. Values followed by a common letter do not differ significantly at the 1% level.

Fertilizer program

In 1981, Dr. R.W. Schneider, UC Berkeley, started a field project at the South Coast Field Station, Santa Ana, on Fusarium yellows of celery, an extremely difficult disease to control. He compared different fertilizer programs on celery grown in soil heavily infested with the strain of *Fusarium oxysporum* that causes celery yellows and found that some of the treatments reduced disease severity.

From his work, we selected five fertilizer programs to test against the *Fusarium* organism that is pathogenic to *Hebe* 'Co-ed'. Plants were propagated from cuttings in a sterile soil medium, inoculated with a suspension of spores from the *Hebe* isolate of *F. oxysporum* sprayed onto the roots, and planted in sterile UC mix without added nitrogen, phosphorus, or potassium. From day one, each group of replicates was fertilized twice a week with one of the following treatments: (1) calcium nitrate plus monobasic sodium phosphate and potassium chloride, (2) calcium nitrate plus monobasic sodium phosphate, (3) ammonium sulfate plus monobasic sodium phosphate, (4) calcium nitrate plus potassium chloride, or (5) ammonium nitrate plus monobasic sodium phosphate and potassium chloride.

Plants grown with treatment 1 were not diseased after three months, whereas 83 percent of the plants grown with treatment 3 were seriously affected, and some were dead. Disease effects in the other treatments were intermediate.

Confirming tests

To check these results, we conducted a second and larger trial with changes:

(1) Inoculum. The *Hebe* isolate of *F. oxysporum* was grown on sterile, ground barley straw that had been amended with L-Asparagine. This culture was then incorporated into the sterile planting medium for the young *Hebe* 'Co-ed' plants.

(2) Fungicides added. Because of the new inoculation procedure, a fungicide drenching program seemed more likely to be effective. In the first trial, the root systems had been covered with infective propagules, whereas in this more natural system, the propagules were mixed in the soil just before planting.

In this second trial, plants were grown three months in ½-liter pots and then transplanted into artificially infested soil in 4-liter, black plastic pots. Plants in infested soils received one of two fertilizer programs with or without one of two systemic fungicides. They were compared with plants grown in noninfested soil with the same fertilizer programs and without fungicides.

Fertilizers were dissolved in water and applied as a regular feed at 200 ml per pot twice a week throughout the trial. Water was supplemented as needed. Half of the plants received calcium nitrate plus monobasic sodium phosphate and potassium chloride (200 ppm nitrogen, 46 ppm phosphorus, and 444 ppm potassium). The other half received ammonium sulfate plus monobasic sodium phosphate (200 ppm nitrogen and 46 ppm phosphorus).

The fungicides were benomyl or imazalil. Benomyl was applied as a drench on replicated plants of both fertilizer treatments at a rate of 600 ppm, with 200 ml applied per pot every 14 days, for a total of four applications. Imazalil was applied as a drench on other replicated plants of both fertilizer treatments at 300 ppm, with 200 ml applied per pot every 14 days, totaling four applications.

Results

The program using calcium nitrate plus phosphorus and potassium chloride produced significantly more healthy plants than did the ammonium sulfate program after 72 days of growth in the greenhouse (table 1). We determined the presence or absence of the disease in each plant by its outward appearance and by cutting into several stems to detect any vascular discoloration. In this experiment, fungicides did not appear beneficial in the calcium nitrate treatment, but benomyl was slightly beneficial when used with the ammonium sulfate program.

After an additional 40 days of growth under the same treatment procedure, each plant was cut off at the soil level and the top weighed immediately. Inoculated plants in the calcium nitrate program did not differ significantly from those grown without inoculum, whereas those fertilized with ammonium sulfate were seriously affected by disease (table 2). In the ammonium sulfate program, benomyl appeared to be helpful.

Conclusion

Where this vascular wilt disease exists in production nurseries, the fertilization program of calcium nitrate, phosphorus, and potassium chloride is likely to help protect new container plants started from those free of *Fusarium oxysporum*. All diseased plants should be destroyed, and the soil in which they were grown fumigated.

Because *F. oxysporum* is a difficult fungus to kill, it would be wise to reuse the fumigated soil with plants other than *Hebe*. The new clean plants should be placed in the nursery away from earlier plantings of *Hebe* that were found diseased, and an added preventive treatment of early drenchings with benomyl would be advisable.

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