recommended rate for young trees, until the groves begin to bear fruit. As the trees approach maturity, P applications can be limited to once every few years. Diagnostic information from leaf and soil testing can help determine whether P fertilization is necessary. Citrus yields have not been correlated with the results of soil tests measuring P levels in calcareous soils; however, soil testing with Mehlich 3, sodium bicarbonate, or another suitable extractant still can be useful in estimating the magnitude of accumulated P. An increased level of P measured by soil tests following periodic fertilization would indicate an increase in available P above the native soil level.

Leaf tissue testing can be used to determine whether soil P is available to citrus trees. For best results, the leaf P concentration of 4- to 6-month-old spring flush leaves from mature trees should be evaluated. The optimum range for leaf P in mature citrus leaves is from 0.12% to 0.16% on a dry weight basis. A decline in leaf P concentration from optimum to low over several years indicates declining soil P availability and justifies a P fertilizer application.

Potassium. For citrus on noncalcareous soils, nitrogen and potassium fertilizer applications with a 1:1 ratio of N to K_2O are recommended. If leaf testing on calcareous soils reveals that high levels of soil Ca may be limiting K uptake, the K_2O rate should be increased by about 25%. This approach may not work in all situations, however. Another way to increase leaf K concentration is through foliar application of KNO_3. A solution of 20 lbs KNO_3 per 100 gallons of water, sprayed to the point of foliar runoff, has been shown to raise leaf K, especially if applied several times during the year. Concentrations greater than 20 lbs KNO_3 per 100 gallons of water should be avoided, since high salt levels promote leaf burn. The availability of N applied through foliar spray equals that of N applied in regular ground fertilizer programs. Therefore, the amount of N applied as KNO_3 should be considered when determining annual N fertilization plans for citrus groves.

Zinc and manganese. The most common inorganic Zn and Mn fertilizers are the sulfates ($ZnSO_4$, $MnSO_4$) and the oxides (ZnO, MnO). Broadcast application of these compounds to correct Zn or Mn deficiencies in calcareous soils is not recommended, since the alkaline pH renders the Zn and Mn unavailable almost immediately. Zinc is also available in chelated forms, including Zn-EDTA and Zn-HEDTA. A **chelate** is a large organic molecule that "wraps around" a micronutrient ion such as Zn^{2+}, sequestering it from soil reactions that make it unavailable. Chelated Zn is sometimes, but not always, superior to inorganic Zn sources. Soil applications of chelated Zn are rarely economical, however. Manganese chelates have limited effectiveness in calcareous soils and are not normally used.

The least expensive way to apply Zn and Mn to citrus is through foliar sprays. In addition to the forms listed above, a number of other Zn and Mn formulations are available for foliar spraying, including nitrates and organically chelated forms using lignin sulfonate, glucoheptonate, or alpha-keto acids. Preliminary research data indicate little difference in magnitude of foliar uptake, regardless of the form of carrier or chelate applied. Similarly, foliar applications of low rates of Mn or Zn (e.g., 0.5 to 1.0 lb elemental per acre) are not adequate to correct moderate to severe deficiencies often found in soils with high pH values.

Iron. It is not easy to remedy iron chlorosis of citrus trees on susceptible rootstocks planted on calcareous soils. Iron fertilizer formulations are available that can correct chlorosis; however, the required application rate and frequency make the treatment expensive. Inorganic sources of Fe such as ferrous sulfate ($FeSO_4$) or ferric sulfate [$Fe_2(SO_4)_3$] are not effective unless applied at extremely high rates; these sources should not be used on calcareous soils. Iron chlorosis should be addressed through soil application of Fe chelates. Chelates are superior sources of Fe for plants because they supply sufficient Fe at lower rates than are required with inorganic Fe sources. The most popular synthetic organically chelated forms of Fe include Fe-EDTA, Fe-HEDTA, Fe-DTPA, and Fe-EDDHA. The effectiveness of these fertilizers varies greatly, depending on soil pH (see Table 3). Fe-DTPA may be used on mildly alkaline soils (with pH values of 7.5 or less), whereas Fe-EDDHA is the chelate of choice for use on highly calcareous soils (with a pH value greater than 7.5).

Natural, organically complexed Fe exists in organic waste products such as sewage sludge, but at lower concentrations than in chelated Fe fertilizers. On calcareous soils in the western United States, sludge applied at 15 tons per treated acre was an effective Fe source for field crops severely deficient in Fe. The efficacy of sludge as an Fe fertilizer for