sufficiency level for use with citrus grown on Florida calcareous soils.

THE EFFECT OF $CaCO_3$ ON ZINC AND MANGANESE

Soil pH is the most important factor regulating Zn and Mn supply in alkaline soils. At alkaline (high) pH values, Zn and Mn form precipitous compounds with low water solubility, markedly decreasing their availability to plants. A soil pH value of less than 7 is preferred to ensure that Zn and Mn are available to plants in sufficient amounts. The soil around a plant root (the rhizosphere) tends to be acidic due to root exudation of H^+ ions. Therefore, soils that are slightly alkaline may not necessarily be deficient in Zn or Mn. In addition, Zn and Mn can be chelated by natural organic compounds in the soil, a process that aids the movement of these nutrients to the plant root. On highly alkaline soils, however, Zn and Mn deficiencies are not uncommon. Soil applications of Zn and Mn fertilizers are generally ineffective in these situations, but deficiencies can be corrected through the use of foliar sprays.

THE EFFECT OF $CaCO_3$ ON IRON

Calcareous soils may contain high levels of total Fe, but in forms unavailable to plants. Visible Fe deficiency, or Fe chlorosis, is common in citrus. The term **chlorosis** signifies a yellowing of plant foliage, whereas Fe **deficiency** implies that leaf Fe concentration is low. Owing to the nature and causes of Fe chlorosis, however, Fe concentration is not necessarily related to degree of chlorosis; in chlorotic plants Fe concentrations can be higher than, equal to, or lower than those in normal plants. Thus, this disorder on calcareous soils is not always attributable to Fe deficiency; it may be a condition known as **lime-induced Fe chlorosis.**

Iron is considerably less soluble than Zn or Mn in soils with a pH value of 8; thus, inorganic Fe contributes relatively little to the Fe nutrition of plants in calcareous soils. Most of the soluble Fe in the soil is complexed by natural organic compounds. (Fe nutrition in plants has improved in response to the application of sewage sludge, which contains organically complexed Fe.) The primary factor associated with Fe chlorosis under calcareous conditions appears to be the effect of the bicarbonate ion (HCO_3^-) on Fe uptake and/or translocation in the plant. The result is Fe inactivation or immobilization in plant tissue.

Susceptibility to Fe chlorosis depends on a plant's response to Fe deficiency stress, which is controlled genetically. Citrus rootstocks vary widely in their ability to overcome low Fe stress (see Table 2). The easiest way to avoid lime-induced Fe chlorosis in citrus trees to be planted on calcareous soils is to use tolerant rootstocks. Existing Fe chlorosis can be corrected by using organic chelates, a method discussed in detail in a later section.

FERTILIZER MANAGEMENT ON CALCAREOUS SOILS

Nitrogen. Regardless of the initial form applied, essentially all N fertilizer ultimately exists as NO_3^- because nitrification proceeds uninhibited in calcareous soils. Rather than attempt to slow this process, citrus grove management practices should emphasize irrigation and fertilizer application scheduling strategies that decrease N leaching. These include irrigating based on tensiometer readings or evapotranspiration measurements and using split applications of N fertilizer. Applying a portion of the required N fertilizer with irrigation water (i.e., through fertigation) and scheduling irrigations to maintain the N in the root zone is a sound method to prevent large N leaching losses. Using controlled-release N also can increase N fertilizer efficiency.

Management of N fertilizer also should involve practices that minimize its loss through ammonia volatilization. Following an application of ammoniacal-N to the surface of a calcareous soil, the fertilizer should be moved into the soil profile with irrigation water if rainfall is not likely. Urea applied to the surface of any soil, regardless of its pH value, should be moved into the soil via rainfall or irrigation. Fertigation using either of these N sources is a suitable application method, provided that there is ample time to flush the fertilizer out of the lines and into the soil.

Phosphorus. To maintain P availability to citrus on calcareous soils, water-soluble P fertilizer should be applied on a regular, but not necessarily frequent, basis. Since phosphorus accumulates in the soil, it is at least partially available as it converts to less soluble compounds with time. Phosphorus deficiency has never been found in citrus grown on Florida calcareous soils where P fertilizer has been applied regularly.

Phosphorus fertilizer should be applied each year in newly planted groves, at a rate based on the