COMPOSTED MUNICIPAL WASTES INCREASE GROWTH, YIELD AND DISEASE TOLERANCE OF CITRUS

By

J. H Graham
Soil Microbiologist
Citrus Research and Education Center
Lake Alfred, FL 33850

SUMMARY

Most citrus grove soils in Florida are infested with *Phytophthora nicotianae*, which causes Phytophthora trunk and root rot resulting in decline of tree condition and fruit production. The potential for composted municipal solid waste (CMW) as a soil amendment to provide long-lasting suppression of *P. nicotianae* and enhance root health and tree yield was evaluated. CMWs were applied to newly planted young trees and bearing citrus groves in central ridge and east coast flatwoods locations. Young trees were planted on typical citrus soils, while bearing trees in decline were located on marginal soils. Two sources of CMW were applied as 5- to 10-cm-thick mulch layers under the tree canopy. Rhizosphere population densities of *P. nicotianae* were not reduced, but in some cases were increased by CMW. Root density response was site-dependent. Trees treated with CMW were more densely foliated probably due to improved soil moisture availability. Young trees responded immediately to CMW treatment with 20-30% increases in stem caliper and root mass. Yields and fruit size of bearing trees were increased in the second and third seasons after application. CMW did not suppress the root pathogen, *P. nicotianae*, but CMW increased water and nutrient availability in soils low in organic matter which enhanced root health and uptake efficiency, and thereby reduced the impact of fibrous root disease and probably other soil stresses.

INTRODUCTION

Citrus is the most economically important and widely planted crop in Florida covering about 273,000 ha in central and south Florida. The center of the citrus industry is within a 100-mile radius of over 7 million people producing 5 kg of solid waste per person per day. Between 1992 and 1994, over 10.3 million new trees were planted on sandy soils, mostly low in organic matter, and poor in nutrient exchange and water holding capacity.

In citrus nurseries and groves, *Phytophthora nicotianae* Breda de Haan (synonym = *P. parasitica* Dastur) is often an endemic root pathogen that causes girdling of the trunk due to bark infection and slow decline in canopy vigor and fruit production due to rot of fibrous roots (Graham and Timmer, 1992). Applications of the fungicides control fungal infection of bark and roots and increase fibrous root density (Timmer et al, 1989). Although fungicides increase yields and fruit size of orange and grapefruit trees on Phytophthora-susceptible rootstocks, yield response is often variable. Therefore, fungicides are not recommended unless populations of *P. nicotianae* exceed a threshold of 10 to 15 propagules per cm^3 of soil. Fungicides are usually applied to the soil through the irrigation system two to three times over several seasons to be effective and economical for application. However, soil-applied pesticides are prone to loss of efficacy after prolonged usage and, since they are water soluble, have the potential to leach into the groundwater after excessive irrigation or rainfall (Kookna et al., 1995). Fungal resistance to the metalaxyl has been found in Florida nurseries, raising concerns about the long-term usage of this fungicide in citrus groves (Timmer et al., 1998).

An alternative strategy to fungicides for sustained control of soilborne diseases is to periodically apply composted organic materials as amendments to suppress fungal root pathogens. Composted bark, when incorporated into potting media, suppresses soilborne diseases of ornamental plants (Hoitink and Grebus, 1994). In Australian avocado groves, root rot caused by *P. cinnamomi* was effectively controlled by intensive mulching with organic amendments and applications of gypsum (Broadbent and Baker, 1974).

In our studies of citrus, CMW from different sources reduced the incidence of root infection of citrus seedlings through direct suppression of *P. nicotianae* in soil (Widmer et al., 1998a). Thus, the principal objective of field studies was to examine the potential for CMW, from different sources applied as a mulch layer on the soil surface, to suppress *P. nicotianae* and improve root health. Growth of young trees and yield of bearing citrus trees was evaluated in typical and marginal soil types with damaging soil populations of the pathogen.

RESPONSES OF YOUNG TREES TO CMW

Three trials from 1991-1996 demonstrated that mulch treatments of composted municipal wastes (CMW) are highly effective for growth stimulation of young citrus trees in newly established groves (Widmer et al., 1996,1998b). Responses were seen for soils typical of both the ridge and flatwoods production areas. While greenhouse bioassays predicted that CMW might suppress the pathogen (Widmer et al., 1998a), populations of *P. nicotianae* were either not affected or even increased by CMW. Despite inoculation with the pathogen, stem diameter and root mass of young trees increased 20-30% in response to post plant treatments with surface mulches as well as incorporation treatments at planting. Thus, CMW can be applied to existing groves without incorporation of the material into the root zone. Operationally, the CMW is effectively and efficiently applied with a New Holland 3000 side-discharge spreader as a 5-10 cm thick mulch layer within the tree row to cover about 80% of the root system. The rates are quite high, ranging from 150-170 metric tons per hectare, but last up to 2 years before reapplication is necessary. Reduction of mulch layers to 2-5 cm thick decreases the tree response and may require yearly re-application to be effective.

Current trials are to designed to establish the optimum rate of CMW and the mechanism for the growth enhancement of young citrus in low organic matter sandy soils. Although CMW increased growth of trees in the presence of *P. nicotianae*, the fungus was not suppressed by the CMW (Widmer et al., 1996,1998b). Despite pathogen activity in CMW-amended soils, the trees performed nearly as well as those in noninfested soils and significantly better than those in nonamended soils. The growth response is best explained by increased tolerance to the disease rather than pathogen suppression. Tolerance is attributed to improvement of conditions in the root zone for more efficient water and nutrient uptake. Young trees received adequate fertilizer and scheduled irrigation so CMW did not substantially increase their nutrient status. Soil water holding capacity was elevated at the interface between the mulch and the mineral soil, as was soil temperature. The proposed major benefit of CMW, increased soil water availability to tree roots, will be substantiated by further measurements of soil and plant water relations.

RESPONSES OF BEARING TREES TO CMW

CMW applied as 5- to 10-cm-thick mulch layers increased the yield and fruit size of Marsh grapefruit and fruit size of Valencia orange 2 and 3 years after application (Widmer et al., 1997). The responses occurred in groves with marginal soils and ill-adapted rootstocks that were predisposed to damaging populations of *P. nicotianae*. The effect of CMW on root density was site specific. CMW increased root density of the Valencia sweet orange trees on Carrizo citrange rootstock in a high pH, calcareous soil, whereas, CMW decreased root density of the Marsh grapefruit trees on sour orange rootstock in a low organic matter sand soil (depressional sand soak) at two sites. The roots in the organic mulch layer were usually lighter in color and healthier in appearance than those in the mineral soil below. The mulch layer apparently provided a zone of favorable conditions for growth and function of fibrous roots.

The increase in yield of trees in very sandy, slightly acid soils versus the non response in calcareous, alkaline soils may be related to the effect of CMW on root density at the different sites. Trees in the very well drained sand soak soil treated with CMW were more densely foliated and showed little sign of water stress compared to the stressed, nontreated trees. CMWs have slow mineralization rates, due to their moderate to high C/N ratios (Eichelberger, 1994), so mulches did not increase N status of the tree (Widmer et al., 1997). The mulches substantially improved moisture holding capacity of the soil as demonstrated for CMW applications to other Florida crops in similar soils (Obreza and Reeder, 1994; Turner et al., 1994). Under more favorable conditions for water uptake, apparently fewer roots were required to take up water and water mobile nutrients (e.g. N and K) bringing about a 30% decrease in root density after CMW application in well-drained sand soak soil. Hence, trees were able to produce more and larger fruit instead of supporting the high density of roots required by a tree in the low water and nutrient holding capacity sand. In finer textured, high pH calcareous sand, where root density was 25-35% of that in the sandy soil, CMW apparently exacerbated the soil conditions (high calcium and somewhat alkaline pH) that normally limit performance of certain

rootstocks like Carrizo citrange (Castle et al., 1993). Although the mulch layer provided a favorable site for root growth in calcareous soil, yield of trees was not increased even after 3 year.

Thus, as for young trees, the principal effect of the CMW was improvement of soil water holding capacity. This condition enhanced pathogen reproduction in the mulches because *P. nicotianae* was favored by elevated soil moisture (Duncan et al., 1993). However, CMW appeared to increase tolerance to Phytophthora root rot. The benefits of CMW for increasing water and nutrient availability in soils low in organic matter enhanced root health and uptake efficiency, and thereby reduced the impact of fibrous root disease and probably other soil stresses as well.

CURRENT STATUS OF RESEARCH ON CITRUS

Some limitations in the use of CMW have been encountered. Foremost is the availability of high quality sources of CMW near the citrus industry that can be supplied with minimal delivery cost. Most of the research has been conducted with a co-composted municipal solid waste (approx. 90%) with waste water residuals (10%) from Sevierville, TN supplied by Bedminster Bioconversion. Co-composted CMW has a favorable C/N ratio for microbial activity (19:1) and slow soil mineralization of nitrogen (Eichelberger 1994) so nitrogen leaching is not a concern.

The local CMW tested in the early 1990s is no longer available (Reuter) and evaluation of CMW from Palm Beach County has only recently been initiated. A grower/cooperator conducted a preliminary trial with Palm Beach CMW in 1996 and reported that the material was very fibrous containing palm branch wastes and other coarse woody residuals that made spreading difficult. The Palm Beach material may also have been high in salts, but thus far, residual salts in the Bedminister CMW have not been a problem for citrus in contrast to the experience for vegetables where growth of the first crop is reduced initially (Obreza 1995). Very sandy soils facilitate rapid leaching of salts and thus, no effect on perennial citrus trees have been observed over the longer term (at least one year to detect growth responses). The Palm Beach material spread in 1997 did not share the problems experienced with the 1996 material, but this points out the requirement for CMWs to be consistent in quality through time if they are to be used commercially.

Another major limitation to proceeding with further trials is the availability of a commercial applicator with the New Holland or equivalent spreader in south-central Florida. Two cooperators representing about 25,000 acres of commercial grove land are at present unable to use CMW due to the lack of the appropriate application equipment. These companies are unwilling to purchase a spreader given the high capital cost (approx. $10,000-14,000) and the uncertain availability of high quality CMW. Nevertheless, our results have stimulated their interest in further trials of local CMW sources, especially in low organic matter, sandy soils. Current evaluation of the benefits of CMW mulches is focused on both young and old groves in depressional sand soils, where citrus trees have not responded to extra water and nutrient inputs and, thus, are probably not manageable without soil amendments. Reduced rates of CMW sources produced by local munipalities in close proximity to the citrus industry are now under evaluation to further quantify the benefits and costs of CMW applications. Although the responses are positive, it is unlikely that the horticultural benefits will offset the high cost of production and transport of CMW. However, as land fill space disappears, the cost of production and transport of CMW will eventually be borne by the municipalities surrounding the citrus industry. For example, Los Angeles County is now paying citrus growers to accept yard wastes for disposal in their citrus groves (J. A. Menge, University of California, Riverside, personal communication).

LITERATURE CITED

Broadbent, P. and Baker, K. F. 1974. Behavior of *Phytophthora cinnamomi* in soils suppressive and conducive to root rot. Aust. J. Agric. Res., 25:121-137.

Castle, W. S., Tucker, D. P. H., Krezdorn, A. H., and Youtsey, C. O. 1993. Rootstocks for Florida citrus. University of Florida, IFAS, SP 42.

Duncan, L. W., Graham, J. H., and Timmer, L. W. 1993. Seasonal patterns associated with *Tylenchulus semipenetrans* and *Phytophthora parasitica* in the citrus rhizosphere. Phytopathology, 83:573-581.

Eichelberger, A. S 1994. Characterization and mineralization of municipal solid waste compost. M. S. Thesis. University of Florida.

Graham, J. H. and Timmer, L. W. 1992. Phytophthora diseases of citrus. Pages 250-269 in: Plant Diseases of International Importance. Vol. III. Diseases of Fruit Crops. J. Kumar, H. S. Chaube, U. S. Singh, and A. N. Mukhopadhyay, eds. Prentice-Hall, New Jersey.

Hoitink, H. A. J. and Grebus, M. E. 1994. Status of biological control of plant diseases with composts. Compost Sci. Util. Spring Issue: 6-12.

Kookna, R. S., Di, H. J., and Aylmore, L. A. G. 1995. A field study of leaching and degradation of nine pesticides in a sandy soil. Aust. J. Soil Res. 33: 1019-1130.

Obreza, T. A. and Reeder, R. K. 1994. Municipal solid waste compost use in tomato/watermelon successional cropping. Soil Crop Sci. Soc. Fla. Proc. 53:13-19.

Timmer, L. W., Graham, J. H., and Zitko, S. E. 1998. Metalaxyl-resistant isolates of *Phytophthora nicotianae*: occurrence, sensitivity and competitive parasitic ability on citrus. Plant Dis. 82:254-261.

Timmer, L. W., Sandler, H. A., Graham, J. H., and Zitko, S. E. 1989. Phytophthora feeder root rot of bearing citrus: Fungicide effects on soil populations of *Phytophthora parasitica* and citrus tree productivity. Proc. Fla. State Hort. Soc. 102:5-9.

Turner, M. S., Clark, G. A., Stanley, C. D., and Smajstrla, A. G. 1994. Physical characteristics of a sandy soil amended with municipal solid waste compost. Soil Crop Sci. Soc. Fla. Proc. 53:24-26.

Widmer, T. L., Graham, J. H., and Mitchell, D. J. 1996. The effect of composted municipal waste as a soil amendment on the growth of young citrus trees and *Phytophthora nicotianae*. Soil Crop Sci. Fla. Proc. 55:32-36.

Widmer, T. L., Graham, J. H., and Mitchell, D. J. 1997. Potential use of composted municipal waste for management of Phytophthora root rot of bearing citrus. Proc. Fla. State. Hort. Soc. 110:46-50.

Widmer, T. L., Graham, J. H., and Mitchell, D. J. 1998a. Composted municipal waste reduces infection of citrus seedlings by *Phytophthora nicotianae*. Plant Dis. 82:683-688.

Widmer, T. L., Graham, J. H., and Mitchell, D. J. 1998b. Composted municipal waste sources and application methods for growth promotion of young citrus trees infested with *Phytophthora nicotianae*. Biol. Fert. Soils (In press).