Citrus Tree Removal Method Does Not Affect Performance of Reset Trees

Stephen H. Futch[1,4], James H. Graham[2], and Larry W. Duncan[3]

Additional index words. citrus nematodes, clipping, *Ganoderma* spp., *Phytophthora nicotianae*, pushing, replant trees, tree shearing, *Tylenchulus semipenetrans*

Summary. Florida citrus groves of sweet orange (*Citrus sinensis*), tangerines (*Citrus reticulata*), and grapefruit (*Citrus paradisi*) experience an annual tree loss of 3% to 4% due to various causes of tree decline. Commonly used tree removal methods in Florida include "pushing," which lifts most of the root system completely out of the soil, or "clipping," which shears the tree off above the soil line leaving the tree stump and root system in place. Several operational and economic advantages and disadvantages exist for both tree removal systems. There are also potential problems with citrus resets that can occur due to foot rot (*Phytophthora nicotianae*) and citrus nematodes (*Tylenchulus semipenetrans*) that remain in the soil after tree removal. To investigate reset tree performance after "pushing" versus "clipping," a study was conducted in three groves representative of three production regions in Florida to compare the impact of tree removal method on the pest/pathogen status and growth of resets over a period of 4 years. Based on the findings, tree removal by "pushing" or "clipping" appears to have minimal effect on subsequent pest and pathogen status and performance of citrus resets. Therefore, the method of tree removal should depend primarily on operational and economic considerations.

Florida citrus groves experience an average tree loss rate of 3% to 4% per year (Muraro et al., 2005). Tree loss can be attributed to a number of factors, including, but not limited to, tristeza (citrus tristeza virus), blight (causal agent unknown), foot rot (*Phytophthora nicotianae*), insects, root weevils (*Artipus floridanus, Asynonychus godmani, Pachnaeus opalus, Pachnaeus litus* and *Diaprepes abbreviatus*) (Tucker, 2006), nematodes, and various environmental abiotic factors (hurricanes, freezes, floods, and drought). Rapid removal and replacement of declined trees is essential to maximize grove productivity and profitability over time (Jackson, 1999).

In the past 10 years, removal of trees by "clipping" the tree off above the soil line has become more commonplace. The prevailing practice had been to remove the entire tree and root system by "pushing" the tree completely out of the soil. What impact, if any, the removal method has on the performance of citrus resets has not been documented. Jackson and Davies (1999) suggested that clipping is not a horticulturally sound practice because the root system remaining in the soil is difficult to kill and promotes more resprouting than pushing.

Problems with citrus resets may also occur from citrus root parasites residing in the replant site (Tsao et al., 1989). For example, the previous recommendation to reduce the incidence of bracket fungus (*Ganoderma* spp.) was to remove all wood (stumps and roots) from the soil before planting new trees, as these residual materials provide an inoculum base for the fungi. Although this is still valid, there is a higher cost associated with complete tree removal compared with clipping (shearing) the tree above the soil line and leaving the stump in the soil. Many growers are successfully shearing trees as a way to reduce replant cost without a major impact on young tree replant growth.

Given these concerns, evaluation of the potential advantages and disadvantages of each tree removal method is warranted. The perceived advantages of pushing the tree and removing the root system from the soil are: 1) removal of most of the infested root system from the soil reduces risk of future disease and pest pressure; 2) the site is easier to replant when the soil is free of roots; 3) loosening and mixing the soil profile when uprooting the tree may facilitate the establishment of a newly planted tree and its root system; and 4) tree spacing within the row is not altered as the new tree is replanted exactly where the old tree was removed.

The perceived disadvantages for pushing are: 1) cost of tree removal is higher than for clipping because it takes longer to remove and dispose of the entire tree than the aboveground portion alone; 2) lateral polyethylene irrigation lines may be damaged when the root system is lifted from the soil, thereby necessitating labor and expense to cut, move, and reconnect the irrigation line before and after tree removal; 3) in some cases, soil must be replaced to restore the elevation of the replanting site when a depression is formed by removal of the root system, adding to the expense of tree replanting; and 4) the integrity of raised beds may be compromised when trees are removed from bedded groves.

The perceived advantages of clipping trees are: 1) the cost is lower than that for pushing because the process is quicker and less plant material is disposed of; 2) damage to lateral irrigation lines is avoided; 3) the elevation of the replant site is not altered; and 4) the integrity of the bed is not altered.

The perceived disadvantages of clipping are: 1) the intact root system in the soil can harbor pests and pathogens that may quickly infest

University of Florida, IFAS, Citrus Research and Education Center, Lake Alfred, FL 33850

This study was supported by the Florida Citrus Production Research Advisory Council.

[1]Extension Agent IV, Multi-County.

[2]Professor, Soil and Water Science Department.

[3]Professor, Entomology and Nematology Department.

[4]Corresponding author. E-mail: shf@crec.ifas.ufl.edu.

Units

To convert U.S. to SI, multiply by	U.S unit	SI unit	To convert SI to U.S., multiply by
2.54	inch(es)	cm	0.3937
25.4	inch(es)	mm	0.0394
16.3871	$inch^3$	cm^3	0.0610

the reset; 2) the reset is more difficult to plant due to roots remaining in the site; 3) resets are not evenly spaced in the row because of the need to offset the reset 0.5 m or more away from the tree stump; 4) wood rotting bracket fungi may colonize the stumps and thereby infect the adjacent reset; 5) root sprouts from the remaining stump can create a significant expense for chemical herbicide applications after replanting; and 6) in some cases, the material(s) used to treat and kill the stump may be translocated into the adjacent tree via natural root grafting.

Tree removal costs as reported by participating growers indicate a substantial cost reduction by clipping compared with pushing as the tree removal method. Cost estimates for clipping ranged from $5.65 to $8.00 per tree, whereas pushing ranged from $8.00 to $12.00 per tree. The above noted cost includes estimates for removing and burning the tree, site preparation before replanting, irrigation repair, and a stump treatment when clipping is the chosen removal method.

Noling and Futch (1994) conducted a study where trees were removed by pushing or clipping and then 50% of each of the sites were treated with methyl bromide-chloropicrin in an effort to control root sprouts. This study indicated that sprouts were significantly reduced where trees were pushed compared with clipped and that the application of methyl bromide reduced sprouting on intact stumps. The study, however, did not demonstrate long-term benefit in reset tree growth response to methyl bromide where trees were uprooted. The use of methyl bromide did initially enhance trunk diameter and tree height of reset trees where trees were clipped, indicating the need to control sprouts from the stump remaining in the soil.

Reynolds and O'Bannon (1963) examined the level of nematodes present after removing grapefruit trees in Arizona that were infested with citrus nematode. At the removal site, new replants were planted in the place of infected trees. They found that reset sites had higher soil temperatures that suppressed nematodes. As the trees grew, shade provided by the expanding canopy provided cooler soil temperatures and nematode populations increased with time. Data on the rate of root decomposition was not collected in this study.

Hannon (1963) reported that live lateral roots may be found up to 3 years after tree removal. If root pieces were allowed to sprout, small quantities of feeder roots developed at the point of origin of the sprout. Hannon (1964) also reported that citrus nematodes can survive in the soil for extended periods. In pot studies, nematodes survived for 81 weeks; however, a 10-fold reduction was noted in the first 4 months.

In addition to the above advantages and disadvantages for each tree removal method, the growth of the replant tree may be impacted by the size and health of the adjacent tree (Muraro and Futch, 1999), or by the site being heavily infested with root parasitic nematodes (Duncan, 2005).

Wood-rotting fungi are present in Florida citrus groves (Figs. 1 and 2), in other citrus producing regions around the world (Burns and Klotz, 1975), as well as in urban landscapes and gardens (Hickman and Perry, 2004). Some of the early reports by Reichert (1932) describe a problem associated with fine-textured soils where wooden stakes of chestnuts (*Castanea* spp.), oaks (*Quercus* spp.), or eucalyptus (*Eucalyptus* spp.) infected with wood-rotting fungi were used to brace up citrus trees on sweet lime (*Citrus limettioides*) rooted trees in Palestine. In Florida, Knorr (1973) and others identified bracket fungi as the fungal agent that invaded healthy citrus wood and was isolated from trees with heart rot. In southern Texas, Skaria and Farrald (1989) reported that 'Marrs' sweet orange trees on sour orange (*Citrus aurantium*) rootstock were infected with bracket fungi when replanted into a freeze-killed grove in 1984. Before planting of the new trees, the freeze-killed trees were cut off above the soil line, leaving the trunk and root system in place. A few years later, Skaria et al. (1990) found various fungi on replants of Cleopatra mandarin (*Citrus reticulata*) and Swingle citrumelo (*Citrus paradisi* × *Poncirus trifoliata*) rootstocks at other freeze-damaged locations in southern Texas. Farr et al. (1989) reported on three species of bracket fungi found to infect citrus, *Ganoderma applanatum*, *Ganoderma brownii*, and *Ganoderma lucidum*

Materials and methods

TREE REPLANT STUDIES. To evaluate pushing and clipping methods, a study was initiated in Summer 2002

Fig. 1. Study site where clipped citrus tree bears fruiting bodies of bracket fungus (*Ganoderma applanatum*).

Fig. 2. Young, replanted citrus tree with bracket fungus (*Ganoderma applanatum*) enveloping the trunk.

in groves located in Polk, DeSoto, and western St. Lucie counties to represent the three major Florida citrus production regions (i.e., the central ridge, the flatwoods area of the southwest, and east coast flatwoods, respectively). Groves were selected to represent soil and environmental conditions typical of each region. No preanalysis was conducted at any site. At each grove location, 36 to 48 pairs of adjacent declining trees were removed by randomly pushing one and clipping the other. Pushing was done with a front-end loader to lift the tree and as much of the root system from the soil as possible, leaving the site mostly root-free. Clipping was done with a standard tree shearer mounted on a front-end loader that sheared the tree 6 to 12 inches above the soil surface, leaving the root system intact in the soil. After clipping, the participating growers applied materials to kill the stump to minimize stump or root sprouting. Within 2 to 6 months after either tree removal method, Valencia sweet orange resets were planted in the pushed sites or within 12 to 24 inches of the adjacent clipped stump (Fig. 1). All Valencia sweet orange reset trees were container grown and were on Carrizo citrange (*Citrus sinensis* × *P. trifoliata*) rootstock at the ridge location, half each on Carrizo citrange and Swingle citrumelo at the southwest flatwoods location, and on Volkamer lemon (*Citrus volkameriana*) at the east coast location. Shortly after planting, tree trunk diameter was measured at a height of 2 inches above the bud union and was then measured yearly thereafter. Also, at the time of replanting and at the end of the first, second, and third year, soil samples were collected from each reset and were analyzed for foot rot propagulaes and plant parasitic nematodes as previously described (Duncan, 1989; Graham and Menge, 1999). Samples consisted of 10 soil cores to a depth of 12 inches taken from the root zone of each reset site at all three locations the first year and then annually thereafter at the ridge site. In flatwoods sites, where the parasitic nematodes were not detected, composite samples from clipping versus pushing sites were collected in the third year. All reset sites were visually evaluated for the incidences of fruiting bodies of bracket fungi on roots or remaining tree stumps. Paired *t* tests were used to compare differences in tree size and pest/disease incidence between clipped and pushed sites at each location and tree measurement date. Data for nematodes and fungi were transformed [$\log_n(x + 1)$] before analysis, but untransformed means are reported.

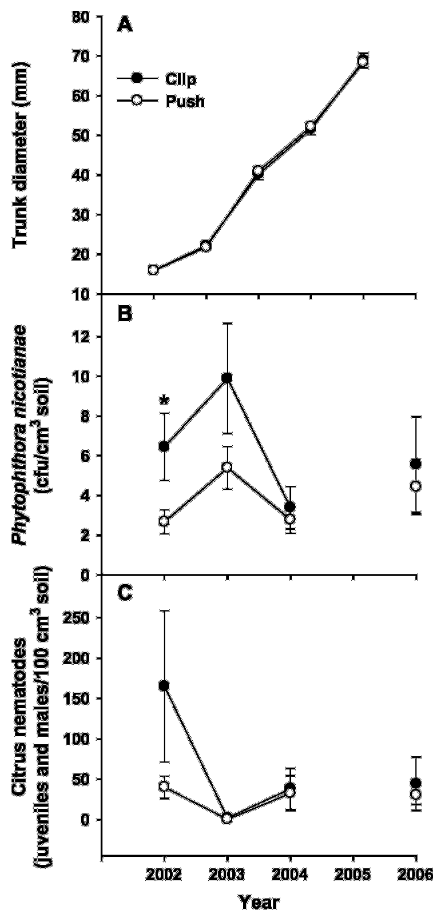

Fig. 3. Comparison of the effect of citrus tree removal method, "clipping" (cutting the tree off above soil line) versus "pushing" (complete removal of citrus tree and root system from soil) on reset tree trunk diameter (A), prevalence of *Phytophthora nicotianae* (B), and *Tylenchulus semipenetrans* (C) in replant sites in the ridge (Polk County, FL). Error bars are SE; *$P \leq 0.05$ according to a paired comparison *t* test, 1 mm = 0.0394 inch, 1 cfu/cm³ = 16.3871 cfu/inch³, and 1 nematode/100 cm³ = 0.1639 nematode/inch³.

Results and discussion

The results from all three locations indicated that reset tree growth as measured by increase in trunk diameter (Figs. 3A, 4A, and 5A) were similar for resets planted into sites treated by clipping or pushing. No negative effects of either tree removal method were detected on tree growth during the 4-year evaluation period.

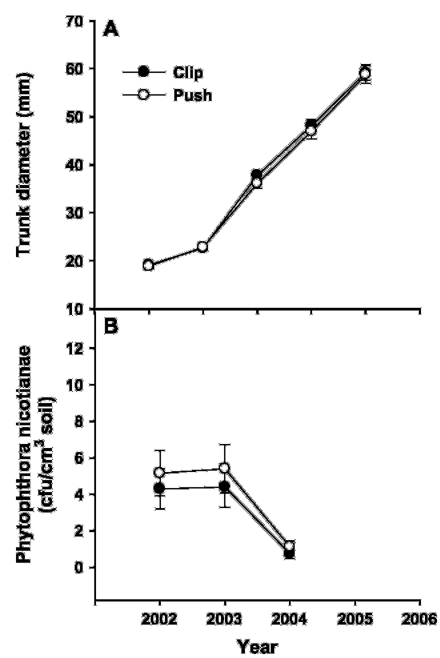

Fig. 4. Comparison of the effect of citrus tree removal method, "clipping" (cutting the citrus tree off above soil line) versus "pushing" (complete removal of citrus tree and root system from soil) on reset tree trunk diameter (A) and prevalence of *Phytophthora nicotianae* (B) in replant sites in the southwest flatwoods (St. Lucie County, FL). Error bars are SE; *$P \leq 0.05$ according to a paired comparison *t* test, 1 mm = 0.0394 inch, and 1 cfu/cm³ = 16.3871 cfu/inch³.

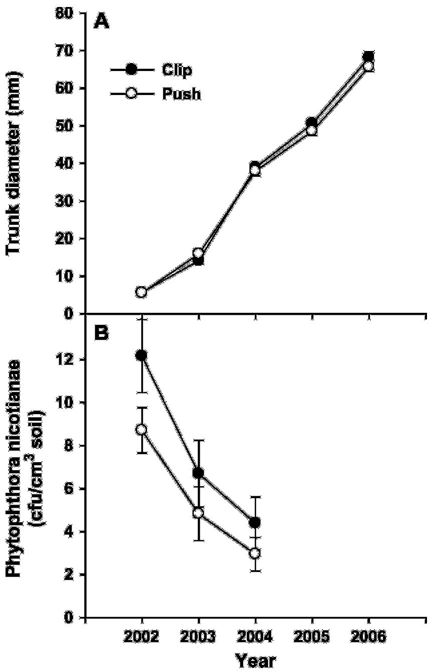

Fig. 5. Comparison of the effect of citrus tree removal method, "clipping" (cutting the citrus tree off above soil line) versus "pushing" (complete removal of citrus tree and root system from soil) on reset tree trunk diameter (A) and prevalence of *Phytophthora nicotianae* (B) in replant sites in the east coast flatwoods (DeSoto County, FL). Error bars are SE; *$P \leq 0.05$ according to a paired comparison *t* test, 1 mm = 0.0394 inch, and 1 cfu/cm^3 = 16.3871 cfu/inch^3.

The similarity of tree growth in clipped and pushed sites may be explained by an absence or lack of difference in pest or pathogen status between the locations. Trees planted into clipped sites supported significantly higher population levels of foot rot propagules only in 2002 at the ridge site (Fig. 3B) where populations exceeded damaging levels on clipped trees (Graham and Timmer, 2007). In subsequent years, the populations dropped below a damaging level, and differences between removal methods disappeared. Phytophthora levels during the study period were unaffected by tree removal method at the other sites.

Citrus nematodes were present at only the ridge location and did not differ between treatments in any year (Fig. 3C). The decline in nematode populations is similar to the results found by Reynolds and O'Bannon (1963), who noted that elevated soil temperatures make young tree sites less conducive for citrus nematode population development.

At all three locations during the 3-year evaluation period of the study, greater than 95% of all citrus stumps were found over time to be infected by one or more bracket fungi (Fig. 1). The number of fruiting bodies per tree stump ranged from one to several that varied in size and shape. However, in only one case was a reset infected. Thus, tree removal by clipping did not significantly promote potential loss of reset trees due to these root rotting fungi.

Based on this data and other field observations, tree removal by pushing or clipping appears to make no difference in the subsequent performance of young replants. The method of tree removal growers choose does not need to reflect the pest/pathogen status of the citrus grove, but can be based primarily on operational and economical considerations.

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