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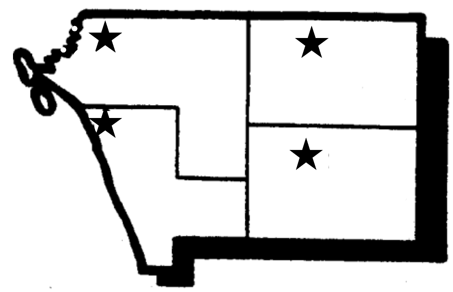
West Central Citrus Letter



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September 20, 2017

Young Tree Leaning after Hurricane

After traveling around after the hurricane, I noticed a number of young trees leaning due to the winds from the hurricane. A question that growers may be asking is should they (young trees) be straighten up or leave them as is.

In the past, a few articles discussed planting trees on a 45 degree angle to regulate tree growth. From those studies, it showed that angle planting did not suppress tree growth. The study showed that the trees produced numerous vertical shoots on the upper side of the main stem. Over time, these new shoots become dominant and will have numerous lateral shoots. Therefore, straightening the tree may not be essential for satisfactory tree growth. For more information on trees growing at an angle, please see the attached article from 1988 by G. F. Piner and published in the Proceedings of the Sixth International Citrus Congress.

If roots from the tree are exposed, then you may consider up-righting the tree as the exposed roots may sprout and create rootstock sprout issues over time.

Flooding Conditions

Dr. Jim Graham and I have written a short article on managing flooded conditions in citrus grove. The article is included as an attachment to this newsletter.

Sincerely,

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Attachments: (2)

Proceedings of the Sixth International Citrus Congress
Tel Aviv, Israel, March 6-11, 1988, R. Goren and K. Mendel (Eds)

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Planting Citrus at Ultra High Densities — A Review of Developments in Southern Africa with Special Reference to Angle Planting

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Abstract

In South Africa and its neighbouring citrus producing countries the claimed benefits of ultra high planting densities, in which trees are planted at more than 1000 to the hectare, have led to growers establishing many such plantings on a semi-commercial scale over the past 4 years. In recognition of the need to couple such plantings with tree dwarfing, growers have used angle planting as a means of reducing the rate of tree growth. In order to provide research backing to these growers, angle planting is being evaluated in both semi-commercial and formal trials. In the recently established formal trials comparisons are being drawn between angle planting, genetic and viral dwarfing. Prominent among the rootstocks being tested are Flying Dragon trifoliate and Yuma citrange. Considerable data has already been accumulated on the dwarfing effect and practical implications of angle planting and certain trends are becoming evident. Results relating to tree growth rates, yield and fruit quality as well as aspects of pruning and training angle planted trees, of a variety of rootstock an scion combinations, are presented. This data suggests that angle planting does not have the desired dwarfing effect for establishing ultra high density plantings.

Introduction

Over the past 14 years a citrus improvement programme has been developed in South Africa and recently the first so called Super-plants have been released to the industry. These trees are free of all known viruses except for a mild cross-protective strain of citrus tristeza virus (CTV), and it is therefore expected that they will grow into large, vigorous trees. This development has been accompanied by increasing economic pressures on citrus growers to improve orchard productivity. A means of doing so is to increase planting densities but this is in itself a complex issue involving healthy but dwarfed trees planted to ultra high densities (UHD).

The probable benefits of UHD plantings, which have in excess of 1000 trees per hectare, are well documented (6,10,11,13). This development is being stimulated by several local factors. In hot production areas the commercial lifespan of grapefruit (*Citrus paradisi* Macf.) has been reduced to 12 to 15 years as a result of CTV and similarly the lifespan of 'Valencia' oranges (*C. sinensis* (L.) Osbeck) is being threatened by the spread of citrus blight. In the cooler Cape province production areas, which are prime areas for future developments in 'Navel' and mandarin (*C. reticulata* Blanco) plantings, orchard productivity is generally low as a result of soil factors and inherent cultivar characteristics. At the same time, land prices in these areas are reaching a premium and a limited availability of irrigation water is a common factor throughout the country. These factors make it imperative that citrus growers maximize productivity, particularly in the early years following orchard establishment.

A pre-requisite for UHD plantings is that tree size must be controlled. Without this such plantings quickly become unmanageable and yield declines as a result of overcrowding and competition (1). In this respect Castle (6) suggests that trees planted at UHD should reach a maximum height of 2.5m.

Current research is aimed at finding an efficient method of controlling tree size and also substantiating the claimed benefits of UHD plantings under local conditions. Initially angle planting was evaluated since this potential method of tree size control had the enormous advantage that conventional rootstock and scion combinations, available in commercial citrus nurseries, could be used. Experiments have been established in each major citrus climatic zone of South Africa and Swaziland and represent all commercially important rootstock and scion combinations. Despite the oldest experiments now only being five years of age, preliminary results are showing important trends. The purpose of this paper is to review the results obtained form angle plantings to date and to also outline the scope of current research into viral dwarfing and dwarfing rootstocks.

Angle Planting

Angle planting is the practice of planting trees at a 30° to 45° angle to the horizontal with the crown of all trees facing the same direction in the row. Within the rows, which are ideally orientated in a north to south direction, the trees are planted at very close spacings. This unique method of planting citrus trees appears to have been first tested in the early 1960s in both Italy (8) and California (12). Indications were that planting at an angle controlled tree size. However in 1981 Burns *et al.* (3) reported that grapefruit and lemons (*C. limon* (L.) Burm. f.) planted at a 45° angle in Ventura County, California, grew vigorously and required excessive hand pruning to contain them. This in turn resulted in unacceptable yields. In 1977 a small angle planting was initiated in the hot citrus production area of Malelane in South Africa. Despite no understanding of the physiology or substantiated evidence for its dwarfing potential, high per hectare yields of 'Valencia' oranges and grapefruit from this planting in the early years have, since 1982, sparked off the establishment of a large number of semi-commercial angle plantings throughout the citrus regions of South Africa and Swaziland. These plantings each range from 0.5 to 20ha in extent and presently it is estimated that in excess of 250,000 trees on approximately 160ha have been angle planted at spacings of 1.2 to 2.0m in the rows and 3 to 5m between rows. The observations and results recorded below are based on both formal trials and semi-commercial plantings.

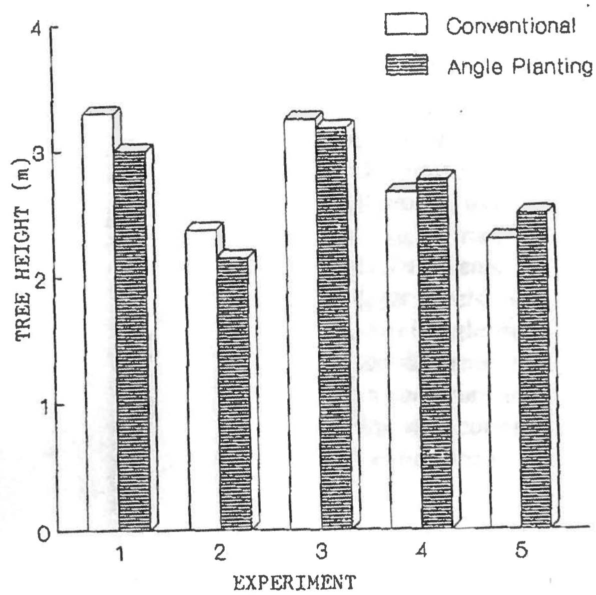
Growth and Production Trends

Observed growth habit of angle planted trees

When planted at a 45° or greater angle from the vertical citrus trees respond in two ways which make the management of these orchards very intensive. Firstly, inherent gravitropic responses cause the trees to assume an upright growth habit. As a result constant attention, particularly in the first two years after planting, needs to be paid to counteracting this tendency. Secondly, angle trees produce numerous vertical shoots along the upper side of the main stem, the scion shoot closest to the bud union being most vigorous. Left unchecked, this shoot becomes dominant and can attain a height of 3.0m or more before any significant lateral branching occurs. Most angle planted trees are dominated by one to three such shoots and regular topping is required to induce branching. The resulting trees generally have a short angle stem 150 to 300mm in length (mainly comprising the rootstock) upon which vigorous upright growing branches have emerged. The original crown of the tree eventually regresses.

Vegetative vigour

Results obtained so far have shown that angle planted trees grow rapidly, especially where vigorous scion cultivars are used. In particular, grapefruit cultivars have grown very vigorously and in comparison to conventionally planted control trees have not shown any signs of being significantly dwarfed. For example, 4.5 year old angle planted 'Marsh' and 'Rosè' grapefruit on trifoliate orange (*Poncirus trifoliata* (L.) Raf.) rootstocks, growing in a hot citrus production area, have already attained a height of 3.4m and a diameter of 3.9m. In similar climatic zones 'Marsh' grapefruit on Troyer citrange (*P. trifoliata* x *C. sinensis*) rootstocks and 'Texas Star Ruby' grapefruit on *C. volckameriana* and Troyer citrange rootstocks have, within five years, exceeded 3.0m in height and are insignificantly smaller than the conventionally planted controls (Fig. 1). Lemons have exhibited similar growth and in a cold citrus production area young angle planted 'Eureka' lemons on rough lemon (*C. jambhiri* Lush) rootstocks have exceeded the size of their controls (Fig. 1).



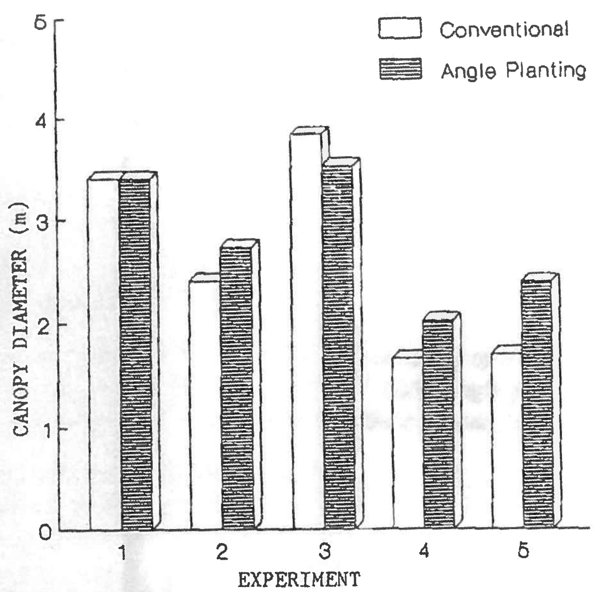


Figure 1: Tree dimensions of five scion and rootstock combinations planted conventionally and at a 45° angle. 1. 4,5 year old 'Marsh' grapefruit on Troyer citrange. 2. 3 year old 'Texas Star Ruby' grapefruit on Troyer citrange. 3. 4,8 year old 'Texas Star Ruby' grapefruit on *C. Volckameriana*. 4. 3,6 year old 'Ellendale' mandarins on Troyer citrange. 5. 2,3 year old 'Eureka' lemons on rough lemon.

Orange and mandarin cultivars, while less vigorous than grapefruit, are beginning to show the same trends, albeit at a slower rate. Angle planted 'Valencia' oranges on trifoliate orange rootstocks in a hot production area have, within 4.5 years, attained a height of 2.9m and a diameter of 2.93m, while three year old angle planted 'Ellendale' mandarins on Troyer citrange rootstocks, in an intermediate climatic production area, have exceeded the size of their controls (Fig.1). In a number of younger experiments of 'Navel' oranges on various rootstocks, in cool and cold production areas, the angle planted trees are marginally smaller than the controls, largely as a result of regular maintenance pruning.

As mentioned, most semi-commercial angle planted orchards have tree spacings of 1.2 to 2.0m in the row and 3.0 to 5.0m between rows and are rapidly becoming overcrowded and unmanageable. Formal pruning experiments, in which angle planted trees were topped at pre-determined heights, have been conducted but regrowth has been too rapid and yields consequently low. Further experiments are now in progress to determine what influence the length of the angle trunk has on tree size. These experiments were initiated in one year old orchards and all shoots were removed from the angled trunks for varying distances between the bud union and crown of the trees.Two years of results from separate experiments involving 'Delta Valencias', 'Palmer navels', 'Ellendale' mandarins and 'Texas Star Ruby' grapefruit all show that a longer angle trunk results in a significantly smaller tree (Table 1). However, the actual differences in tree size are small and may only be due to the pruning which as been necessary to maintain the treatments. The yields of the trees with the longer trunks were correspondingly reduced, but several years of additional data are necessary to confirm these results.

Table 1: Influence of length of the angled trunk on tree size and productivity of three year old 'Ellendale' mandarins on Troyer citange planted at a 45° angle

Length of angled trunk from ground level (unbranched)	Tree height (m)	Canopy diameter (m)	Stem diameter (mm)	Yield (kg/tree)
80–200mm	2.78a*	2.00a*	61.8a*	11.02a
550–600	2.58b	1.72b	52.1b	8.75ab
720–820	2.40c	1.56c	47.3c	8.15b

*Within a column treatment means not sharing the same letters are significantly different at the 5% level.

Productivity of UHD angle plantings

UHD angle planted orchards generally produce a small crop of low quality fruit in their second year after planting. The first significant crop is usually produced in the third year after planting, by which time the internal quality of most fruit can meet export standards, provided suitable rootstocks are used. However on such young trees a relatively large percentage of this crop still comprises fruit which are too large in size to fall into the popular count range. Both internal quality and fruit size become more acceptable in the fourth year. UHD orchards generally outyield their conventional controls but this is solely a function of tree numbers and not due to precocity of the angle planted trees (Table 2). This is because the conventional trees rapidly approach a hedgerow situation whilst the angle trees, which form a hedgerow in their second year, become excessively overcrowded. These results highlight the ideal: a tree which grows rapidly to reach its final, but dwarfed size.

Table 2: Yield of five cultivars on different rootstocks planted conventionally (control) and at a 45° angle in different climatic areas

Scion	Rootstock	Planting method	Climatic area	Tree age (years)	Yield (kg/tree)	Tree density /ha	Yield (tons/ha)
Marsh grapefruit	Troyer citrange	Conventional 45° Angle	Hot	4.5	127.7 36.3	440 1,667	56.19 60.53
Texas Star Ruby grapefruit	Troyer citrange	Conventional 45° Angle	Hot	2.6	56.1 25.1	476 1,428	26.7 35.8
Valencia	trifoliate	Conventional 45° Angle	Hot	4.0	29.4 23.9	666 1,736	19.58 39.05
Palmer navel	*C. volckameriana*	Conventional 45° Angle	Cold	2.3	1.9 0.7	272 1.452	0.524 1.02
Eureka lemon	rough lemon	Conventional 45° Angle	Cold	2.3	11.2 9.5	555 1,333	6.2 12.6

Comparative yield results from formal experiments involving orange cultivars are presently limited to the first crop only, the UHD angle planting showing a 50% yield advantage over conventional plantings (Table 2). However results from a single 4.5 year old semi-commercial planting indicate that for these cultivars, which are less vigorous than grapefruit, the yield advantage of the UHD planting over the conventional planting is greater and likely to be more lasting.

For both grapefruit and orange cultivar angle plantings the internal fruit quality in terms of juice percentage, total soluble solids (TSS), percentage acid, TSS to acid ratio as well as fruit size distribution have not been significantly different to that of conventional trees.

Table 3: A comparison of the performance of four scion cultivars on Yuma citrange and rough lemon rootstocks in a hot citrus production area in Swaziland and a cold citrus production area in the Eastern Cape (means ± SE for at least 9 trees per combination

Locality	Scion	Rootstock	Tree age (years)	Tree height (m)	Canopy diameter (m)	Tree volume (m^3)	Yield (kg/tree)	Yield kg/m^3
Swaziland	Olinda valencia	Yuma citrange	12	2.9 ± 0.2	3.1 ± 0.4	13 ± 1	95 ± 10	9.4 ± 1.2
		Rough lemon	12	4.2 ± 0.2	4.2 ± 0.4	38 ± 3	245 ± 19	7.5 ± 0.7
	Tambor	Yuma citrange	12	3.1 ± 0.3	3.2 ± 0.5	15 ± 2	113 ± 13	8.3 ± 1.3
		Rough lemon	12	4.2 ± 0.8	4.0 ± 0.8	39 ± 7	277 ± 55	6.4 ± 0.2
	Marsh grapefruit	Yuma citrange	12	4.0 ± 0.4	4.4 ± 0.4	37 ± 4	243 ± 21	8.5 ± 0.6
		Rough lemon	12	4.2 ± 0.4	5.1 ± 0.6	53 ± 5	253 ± 29	6.7 ± 0.7
Eastern * Cape	Palmer navel	Yuma citrange	11	2.1	1.96	5.7	47.8	8.3
		Rough lemon	11	3.3	3.14	22.4	98.9	4.4

* Data from Grundlingh et al. (9).

Viral Dwarfing and Dwarfing Rootstocks

During 1985 and 1986 a series of six experiments, each 1 ha in size, were planted to investigate viral and rootstock dwarfing and compare them with angle planting. Each experiment comprises a single scion cultivar, the cultivars being 'Palmer' navels (2 experiments), 'Delta valencias', 'Marsh' grapefruit, 'Texas Star Ruby' grapefruit and 'Lisbon' lemons. The experiments are planted in climatic zones best suited to each cultivar. In each trial a standard tree spacing of 5m x 2m has been used.

Viral dwarfing

Two strains of the exocortis viroid, which produce a mild reaction in Etrog citron (*C. medica* L.), were selected locally for inoculating each of the scion cultivars on Australian trifoliate orange rootstocks. To obtain initial rapid tree growth, so that high yields in the early years can be ensured, inoculation during the nursery stage is being compared with inoculation two years after field planting. The same treatments have also been applied to the grapefruit cultivars and 'Valencia' oranges on Troyer citrange rootstocks.

Dwarfing rootstock

Flying Dragon trifoliate orange. P. trifoliata var. monstrosa (T. Ito) Swing.

Considerable literature concerning the dwarfing nature, compatibility with scion cultivars and productivity of this rootstock has been published (2,4,5,11). Despite the fear that its growth rate may be too slow to ensure high yields in the early years after planting, a considerable portion of each experiment has been devoted to this rootstock.

Yuma citrange

In South Africa this rootstock, also referred to as Sacaton citrumelo, is showing great potential for controlling tree size of orange cultivars. Several years of data have been accumulated from two experimental sites. In a 12 year old experiment, located in a very hot citrus area, Yuma citrange is budded to 'Olinda valencias', 'Tambor' tangors (*C. reticulata* x *C. sinensis*) and 'Marsh' grapefruit. The 'Valencia' and 'Tambor' trees are 38% smaller (on a volume basis) than the same cultivars on the standard rootstock rough lemon (Table 3). Their height does not exceed 3.1m, this being considered a small tree for this area. In contrast 'Marsh' grapefruit is not significantly smaller on Yuma citrange than on rough lemon. Individual tree yields of the 'Valencias' and 'Tambors' are significantly less on Yuma citrange than rough lemon, but on a canopy volume basis yields are better on Yuma citrange (Table 3).

At a second site which is located in a cold citrus production area the canopy volume of 'Palmer' navels on Yuma citrange is approximately 70% less than on rough lemon. Here the trees on 'Yuma citange' are less than 2.1m in height at 11 years of age (Table 3). Yields follow the same trends as in the experiment in the hot area. At the same site 'Valencias' oranges on Yuma citrange are as dwarfed as the 'Navels'. In both experiments fruit size and internal fruit quality of the scions on 'Yuma citrange' are generally better than those on the standard rootstock.

The reason for the Yuma citange trees being dwarfed is unknown. In California trees on this rootstock are not dwarfed (7,11). It is suspected that a virus may be implicated in the dwarfing exhibited in South Africa. A number of treatments involving Yuma citrange have been incorporated in the recently established experiments to elucidate the nature of this dwarfing. In addition information will be obtained concerning its rate of growth and productivity in the early years after planting.

Conclusion

Citrus growers in South Africa are acutely aware of the need to improve their productivity and consequently much interest is being shown in UHD plantings. A large angle number of such plantings have been established on a semi-commercial scale using planting as a means of controlling tree size. Preliminary research results indicate that this practice is unlikely to bring about tree dwarfing, this being a pre-requisite for UHD plantings. The results do however highlight the benefits of UHD orchards, particularly for less vigorous cultivars, and also the need for a dwarf tree which rapidly attains its mature, but dwarfed size.

The importance of finding a method for controlling tree size in UHD orchards has precipitated further large scale experiments to investigate both viral dwarfing as well as dwarfing rootstocks. Of the rootstocks being tested Yuma citrange shows potential as a highly productive dwarfing rootstock for cultivars other than grapefruit.

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Draft – 9/19/17

Managing Flooded Conditions in Citrus Groves*

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Historically, hurricanes in 2004-2005 and periodic tropical storms have caused extensive wind and flooding damage. Even before Hurricane Irma, heavy rainfall in late August created saturated soil conditions in many citrus groves in Southwest and South Central FL. Rains from Irma from September 9-11 were so heavy (greater than 15 inches) that it was impossible to remove the water from the grove rapidly enough to prevent flooding (Figure 1).

If water can be removed quickly, flooding injury may be minimal but potential for water damage to citrus trees increases if water stands over the crown of the tree root system for four or more days under summer temperature conditions (85-95°F). Root injury occurs even when the water table remains just a few inches below the soil surface because soil pores filled with water create a lack of oxygen in the root zone which allows anaerobic bacteria to develop rapidly. Under these conditions, toxic sulfides produced by these anaerobic sulfur-reducing bacteria can build up quickly and kill roots. Ironically, one of the symptoms of excess water is leaf wilting. This occurs because flooding and the lack of oxygen increase root resistance to water uptake. Inadequate aeration decreases water absorption. Nevertheless, transpiration, or the loss of water vapor from leaves, continues. Hence, in hot summer conditions, tree canopy water loss can be greater than water uptake through the roots and wilting occurs. Other symptoms of flood injury include leaf yellowing, chlorosis, fruit drop, leaf drop, and twig dieback. Trees with severely damaged root systems fail to recover, remaining stunted or decline.

In most flatwoods soils, a clay or organic layer within 20-48 inches of the surface acts as a barrier to downward movement of excess water. As a result, water must move laterally to be drained from saturated soils. The rate at which water moves through soil is expressed in units of distance/time (in/hr or ft/day) and is called hydraulic conductivity. Sands typically have saturated hydraulic conductivities of 20 inches per hour or more, while the saturated hydraulic conductivity of many flatwoods clay layers is in the range of 0.1-0.2 inch per hour.

Flooding damage can be determined by digging into the soil and smelling root and soil samples. Sour odors or a rotten-egg smell (indicating hydrogen sulfide) is a sign that fibrous roots are damaged. Vegetative material buried during bed construction can provide the energy source for anaerobic bacteria to reduce sulfates to sulfides. Oxygen deprivation as well as toxic sulfides both contribute to the outright destruction of citrus fibrous roots. Roots will appear dark brown (Figure 2) and slough when pinched between the finger and thumb.

Water table monitoring wells are a good tool for observing soil-water dynamics (Figure 3). They are the most reliable method for evaluating water-saturated zones in sites subject to chronic flooding. Growers can use these wells to measure the rate of water table drawdown. Observation wells constructed with float indicators allow the grower to estimate water table height while driving by the well site. Local offices of the National Resource Conservation Service (formerly USDA Soil Conservation Service) can assist with water table observation well construction and monitoring.

Once excess water has drained and if root damage has not been excessive, trees can begin recovery by regenerating fibrous roots and re-establishing the balance between roots and shoots. Huanglongbing (HLB) damages the very same roots so HLB is very likely to slow regeneration of the fibrous roots system and restoration of the balance between roots and foliage. As recommended for HLB affected trees, efficiency of fibrous roots for water and nutrient uptake is promoted by frequent, short duration applications of irrigation and fertilizer. If wilting of the canopy is visible, trees recovery may be improved by light hedging and topping.

Although flooding may exacerbate Phytophthora root rot, anoxia (lack of oxygen) and toxic sulfides are more likely to kill roots over the short term than Phytophthora. Over the longer term, flooding events elevate the activity of Phytophthora. Therefore, as fibrous roots regenerate it is essential to minimize water stress (deficit or excess) by monitoring irrigation frequency and duration and measuring water table fluctuations into the root zone with monitoring wells. Fungicide treatments to control Phytophthora root rot should be based on soil and root propagule counts (2017-18 Florida Citrus Production Guide section on Phytophthora foot rot and root rot). In summary, flooding requires that tree management be intensified to minimize the effects of stress on water-damaged trees.

In summary, flooding does not always damage tree root systems, but trees should be closely monitored for symptoms. Duration of flooding conditions, rate of water table draw-down, soil type, presence of sulfur or organic matter, tree age, rootstock, and root damage caused by HLB are all factors to be considered when evaluating flooding injury and managing tree recovery. Other cultural practices should be adjusted to minimize stress on water-damaged trees. Once the immediate drainage problem has been alleviated, the approach is observe the tree's response to the flooding event to guide the course of action.

*Adapted from Parsons, L., B. Boman, M. Zekri and J. Graham. 2008. Flooding in citrus groves. Citrus Industry 89(8):22-24.

Draft – 9/19/17

Figure 1

Flooded grove in Arcadia 9-12-17

Figure 2

Healthy fibrous roots

Fibrous root damaged by flooding

Figure 3

Water table monitoring well with float removed