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Growth of Four Citrus Rootstocks Treated with a Natural Biostimulant

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Abstract. **"Roots" (Roots Inc., New Haven, Conn.) a water soluble natural biostimulant is a soil-applied compound consisting of humic acids, marine algae extracts, a plant metabolite, and B vitamins. The effects of "Roots" on the growth of open-pollinated seedlings of sour orange (*Citrus aurantium* L.), 'Swingle' citrumelo (*C. paradisi* Macf. x *C. trifoliata* L.), 'Troyer' citrange (*C. sinensis* Osbeck x *C. trifoliata* L.), and 'Cleopatra' mandarin (*C. reticulata* Blanco) was studied under greenhouse conditions. All citrus seedlings were grown in pots filled with a potting mix (peat, vermiculite and sand) or pure sand. On four occasions spaced at 3-week intervals during an 80-day experimental period, the plants were irrigated with 0.0%; 0.25%; 0.5%; 1.0%; and 2.0% aqueous solutions of "Roots". 'Swingle' seedlings grown in the potting mix had decreased shoot dry weight of 36% and 22% when irrigated with 0.5%, and 1% "Roots" solution, respectively, compared to controls. Sour orange and 'Troyer' seedlings growing in the potting mix and irrigated with 1% "Roots" solution had decreased shoot dry weight of 28% and 35%, respectively, compared to controls, whereas, 'Cleopatra' mandarin had decreased shoot dry weight of 40% when irrigated with 2% "Roots" solution. Independent of plant species, root:shoot dry weight ratio of seedlings growing in the potting mix increased as much as 15% and 21% when irrigated with 0.5% and 1% "Roots" solution, respectively, compared to controls. Root dry weights of each citrus species growing in the potting mix and treated with "Roots" did not differ from controls. All sand-grown citrus seedlings treated with "Roots" did not differ from controls for shoot dry weight, root:shoot ratio, or root dry weight.**

Abstracto. **"Roots" (Roots Inc., New Haven, Conn.) un biostimulante natural soluble en agua es un compuesto que se aplica al suelo y que consiste de ácidos húmicos, extractos de alga marina, metabolito de planta, y vitaminas B. El efecto de "Roots" en el crecimento de plantas de vivero de la naranja amarga de polinización abierta (*Citrus aurantium* L.), 'Swingle' citrumelo (*C. paradisi* Macf. × *C. trifoliata* L.), y mandarina 'Cleopatra' (*C. reticulata* Blanco) se estudió bajo condiciones de invernadero. Todas las plántulas cítricas se cultivaron en macetas llenas de una mezcla de almácigo (turba, vermiculita, y arena) o arena pura. En cuatro ocasiones espaciadas por intervalos de 3 semanas durante un período experimental de 80 días, las plantas se regaron con 0.0%; 0.25%; 0.5%; 1.0%; y 2.0% de una solución acuosa de "Roots". Plántulas de 'Swingle' cultivadas en mezcla de almácigo tuvieron una reducción en el peso seco del tallo de 36% y 22% cuando se regaron con 0.5%, y 1% de solución "Roots", respectivamente, comparado a los controles. Plántulas de naranja amarga y de 'Troyer' cultivandose en la mezcla de almácigo y que se regaron con 1% de la solución "Roots" tuvieron una reducción del peso seco del tallo de 28% y 35%, respectivamente, comparado a los controles, mientras que, la mandarina 'Cleopatra' redujo el peso seco del tallo a 40% cuando se regó con 2% de la solución "Roots". Independientemente de la especie de la planta, la relación raíz:peso seco del tallo de las plántulas cultivándose en la mezcla de almácigo aumento hasta un 15% y 21% cuando se regaron con 0.5% y 1% de la solución "Roots", respectivamente, en comparación a los controles. El peso seco de la raíz de cada una de las especies cítricas cultivándose el la mezcla de almácigo y tratadas con "Roots" no fue diferente a la de los controles. Todas las plántulas de cítricos cultivadas en arena tratada con "Roots" no fueron diferentes a los controles en el peso seco del tallo, relación raíz:tallo, o peso seco de la raíz.**

According to Russo and Berlyn (1990), biostimulants are "non-fertilizer products which have a beneficial effect on plant growth". Some researchers consider biostimulants to positively influence citrus fruit quality (Smith, 1987) but experiments involving foliar sprays with commercial products such as Citrus Ten, By-Pass, Spray-N-Grow, Crop Up, and Triton B-1956 on grapefruit trees (*Citrus paradisi* Macf) produced disappointing results (Fucik and Davila, 1988).

Many of the biostimulants are natural products devoid of any synthetic chemicals. "Roots", which is one such material, was jointly developed by Roots, Inc. and scientists at the Yale University School of Forestry (Berlyn and Russo, 1990). The product is a mixture of humic acids, marine algae extracts, an non-hormonal reductant plant metabolite, and B vitamins.

Some of the constituents in "Roots", e.g. humic acids, were reported to increase growth of mature 'Honey' tangerine (*Citrus reticulata* Blanco) and 'Valencia' orange (*C. sinensis* Osbeck) trees and newly planted 'Ruby Red' grapefruit and 'Hamlin' orange trees (Webb et al., 1988). Moreover, seaweed-based nutrient foliar sprays improved yields of 'Sunburst' tangerine trees (Koo, 1988) and corrected Mg, Mn, Zn, and B deficiency symptoms in sweet orange seedlings (Aitken and Senn, 1964).

"Roots" is marketed as a rot growth enhancer that increases plant water and nutrient uptake and improves plant stress tolerance and vigor (Roots, Inc.). Field and greenhouse studies with this material indicated improved root and shoot growth, increased stress resistance, and better utilization of mineral nutrients in woody plant species such as: loblolly pine (*Pinus taeda*), sand pine (*Pinus clausa*), black walnut (*Juglans nigra*), red maple (*Acer rubrum*) and grasses such as: tall fescue (*Festuca sp.*), bluegrass (*Poa pratensis*), and bentgrass (*Agrostis sp.*) (Russo and Berlyn, 1990). No information on this material, however, is available with regard to citrus.

Widespread replanting of citrus orchards in the Lower Rio Grande Valley of Texas after the devastating freeze of 1989 makes the potential benefits of using "Roots" particularly appealing. Vigorous root growth of newly-planted trees is of the utmost importance for their successful establishment. The aim of this study was to obtain preliminary information on the effect of "Roots" on the vegetative growth of four commercially important citrus rootstocks.

Materials and Methods

Open-pollinated seedlings of sour orange, 'Swingle' citrumelo, 'Troyer' citrange, and 'Cleopatra' mandarin were

The use of trade names does not imply endorsement of the Texas A&I University of the product named, nor criticism of similar ones not mentioned.

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grown under greehouse conditions. They were 12-25 cm tall at the time of treatment.

Seedlings were planted in 1.1 liter square plastic pods filled with pure sand or a potting mix [peat, vermiculite, and sand at 11:6:3 ratio (v/v/v)] and fertilized once a week with an aqueous solution containing (in mM): N – 33, P – 6.6, K – 9.9, Mg – 0.4 and (in *u*M): Fe – 44, S – 34, B – 9.6, Cu – 23.9, Mn – 21.4, Zn – 15.4, and Mo – 0.3. Additionally, every three weeks, plants were fertilized with a 20 *u*M solution of FeEDDHA. The fertilizer solutions were applied at volumes large enough to leach the root media to eliminate the potential for soluble salt accumulation.

Seedlings were irrigated on March 29, April 12, and May 24 with 0%, 0.25%, 0.5%, 1.0%, or 2.0% aqueous (deionized water) solutions of "Roots". The volume of liquid retained was 33 and 8.2 ml per pot filled with the mix and sand, respectively. Thus, with four applications, the actual amount of "Roots" retained in a single pot filled with a mix was 0; 0.33; 0.66; 1.32; and 2.64 ml when irrigated with 0%; 0.25%; 0.5%; 1.0%; and 2.0% solutions of "Roots", respectively. About a quarter of these amounts was retained in pots filled with sand.

The treatments were arranged in a split-split plot design. Growing medium (sand or mix) comprised the main plots, whereas citrus species and concentrations of "Roots" solutions constituted sub- and sub-sub plots, respectively. There were four replications (plants) per treatment.

Aproximately 80 days after treatment commenced, shoot length was measured on all seedlings in the experiement. The seedlings were harvested and divided into leaves, stems, and roots. All the tissues were dried in an oven for 48 hrs at 80C and weighed.

Results

'Swingle' seedlings grown in the potting mix had decreased shoot dry weight when irrigated with 0.5% or 1% "Roots" solution compared to control (Fig. 1). Sour orange and 'Troyer' seedlings grown in the potting mix and irrigated with 1% "Roots" solution had decreased shoot dry weight when compared with their respective controls. In 'Cleopatra' mandarin grown in the mix, reduction in shoot dry weight occurred when seedlings were irrigated with 2% "Roots" solution.

"Roots" had no effect on root dry weight of seedlings grown in the potting mix nor did it affect root and shoot dry weight of seedlings grown in sand regardless of citrus species (data not shown). Also, shoot elongation and shoot lateral growth of seedlings were not affected by "Roots" irrespective of the growing medium and citrus species (data not shown).

Independent of citrus species, root:top dry weight ratio of seedlings growing in the potting mix increased when irrigated with 0.5% and 1% "Roots" solutions compared to control (Fig. 2). Root:shoot dry weight ratio of seedlings growing in sand, however, was not affected by "Roots" regardless of solution concentration.

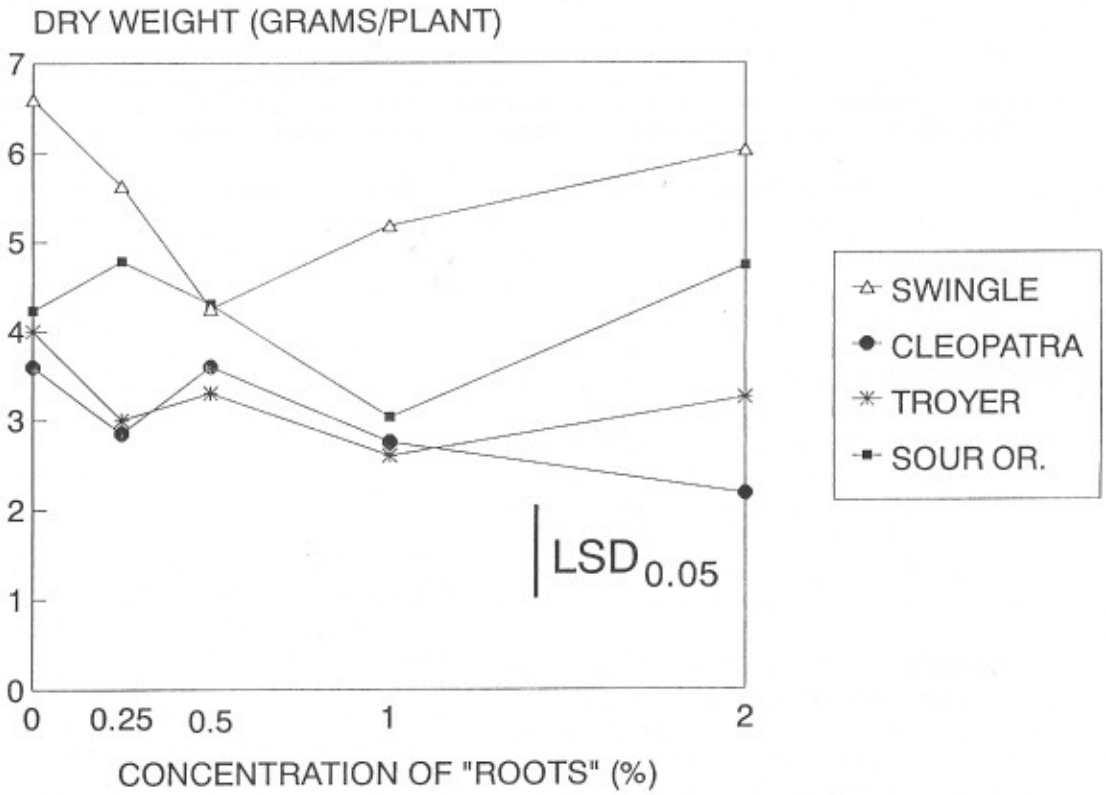

Fig. 1. Shoot dry weight of seedlings of four citrus species grown in a potting mix (peat, vermiculite and sand) and irrigated four times at 3-week intervals with aqueous solutions of "Roots" biostimulant over 80 days.

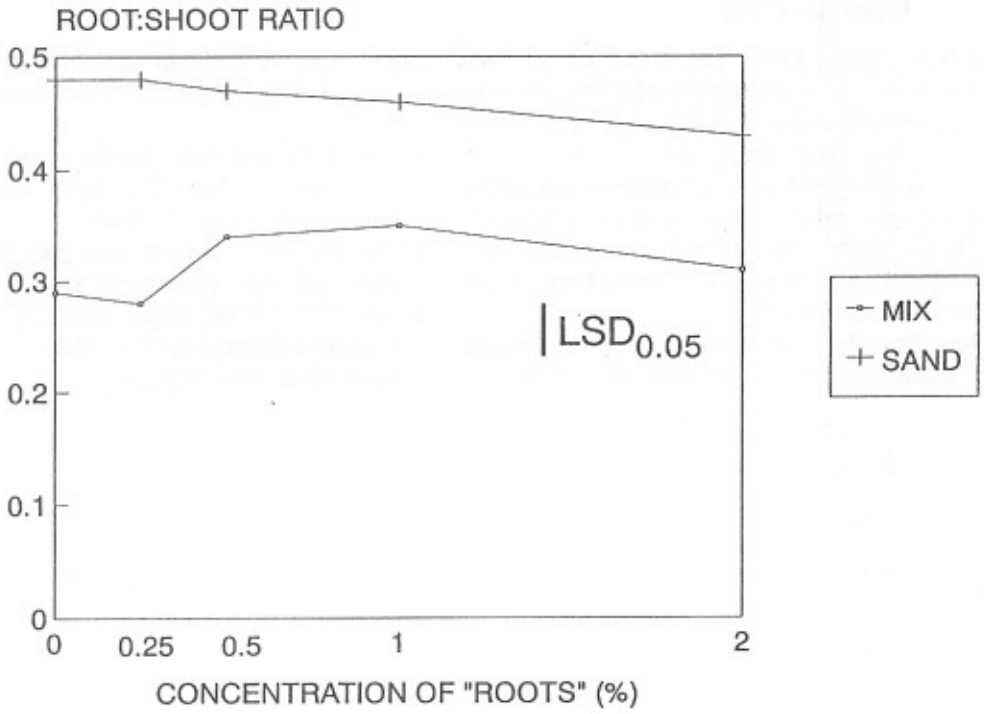

Fig.2 Root:shoot dry weight ratio of seedlings of four citrus species (combined means) grown in a potting mix (peat, vermiculite, and sand) or pure sand and irrigated four times at 3-week intervals with aqueous solutions of "Roots" biostimulant during an 80-day period. The citrus species used were: sour orange, 'Swingle' citrumelo, 'Troyer' citrange, and 'Cleopatra' mandarin. The growing medium x "Roots" concentration interaction was significant at 1% level. Growing medium x "Roots" concentration x citrus species and "Roots" concentration x citrus species interactions were not significant.

Discussion

The elevated root to shoot dry weight ratios in seedlings growing in the potting mix and treated with "Roots" generally agree with Berlyn and Russo's (1990) and Russo and Berlyn's (1990) results except that with the citrus seedlings the differences were caused exclusively by the "Roots"-induced reductions in shoot dry weight (Fig.1) and not, as they reported, by the material's stimulatory effect on root growth. Also, the present study did not confirm the stimulatory effect of "Roots" on shoot growth contrary to the results of studies conducted on loblolly pine, sand pine, and red maple (Russo and Berlyn, 1990). The apparent differences between the results of these studies might be due to the various plant species used. In addition, water and mineral nutrients were non-limiting in my study. Berlyn and Russo (1990) suggested that "Roots" effects may be most pronounced when plants are exposed to water or nutrient stress.

The significant effects of "Roots" on citrus found in this study were rate dependent. For example, the increases in root:shoot ratio were only observed for the intermediate (0.5% and 1%) but not the lowest and the highest concentrations of "Roots". This response compares to data from Webb et al. (1988) on the effect of humic acids, one of "Roots" constituents, on citrus vegetative growth.

The citrus seedlings growing in sand did not respond to "Roots" at any of the concentrations used. The most probable explanation is that the low water holding capacity of sand (approximately one-fourth of the mix) limited the quantity of "Roots" available for plant absorption to an amount insufficient to elicit any growth responses.

The present experiment demonstrated the ability of "Roots" to increase root to dry weight ratio in sour orange, 'Cleopatra' mandarin, 'Swingle' citrumelo, and 'Troyer' citrange. Contrary to earlier reports, however, this response was caused exclusively by a "Roots"-induced reduction in shoot dry weight and not the material's stimulatory effect on root growth. It is unclear how these responses could affect seedlings' resistance to stress.

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