Cultivos Tropicales, 2015, vol. 36, no. 2, pp. 56-61
DOI: 10.13140/RG.2.2.24073.85601
http://dx.doi.org/10.13140/RG.2.2.24073.85601
April-June

ISSN print: 0258-5936
ISSN online: 1819-4087

Ministry of Higher Education. Cuba
National Institute of Agricultural Sciences
http://ediciones.inca.edu.cu

CHARACTERIZATION OF THE VEGETATIVE DEVELOPMENT AND ITS RELATIONSHIP WITH FRUITING AND PRODUCTION OF ORANGE TREES [*Citrus sinensis* (L.) OSBECK]

Caracterización del desarrollo vegetativo y su relación con la fructificación y producción en naranjos [*Citrus sinensis* (L.) Osbeck]

Guillermo R. Almenares Garlobo[1]✉, María del C. Pérez Hernández[2], Walfredo Torres de la Noval[2], Mario Varela Nualles[2] and María I. Pavón Rosales[2]

ABSTRACT. A characterization of the vegetative development of `Valencia Late´ and `Washington Navel` orange cultivars was done and the relationship between vegetative development, fruiting, production and efficiency of the fruiting and production was determined. A plot from each cultivar was selected and during every year's flushing period, the number of leaves per canopy surface, tree dimensions and average foliar surface were evaluated; accumulated rainfall was recorded. Variables like vegetative development, foliar area per tree, foliar area per canopy volume and the foliar area index were estimated. From each variable data, a simple classification analysis of variance was performed every year. Variables as fruiting, production and efficiency of the fruiting and production were calculated and their relationship with those of vegetative development was determined through an Analysis of Canonic Correlations. The results showed that the vegetative development corresponds to the behavior of accumulated annual rainfall, as they increase, the vegetative development is higher. The foliar area was directly related to fruiting and production of both cultivars. Increased foliar area per tree and foliar area reduction per canopy volume mainly contributed to an increased fruiting (number of fruits per tree) and production (kg of fruits per tree).

Key words: *Citrus sinensis*, leaf area, fruiting, plant production

RESUMEN. Se caracterizó el desarrollo vegetativo de los cultivares de naranjo `Valencia Late´ y `Washington Navel`, se determinó la relación del desarrollo vegetativo con la fructificación, la producción y la eficiencia de la fructificación y la producción. Se seleccionó una parcela por cada cultivar y durante cada oleada de brotación, se evaluó el número de hojas por superficie de la copa, las dimensiones de los árboles y la superficie foliar promedio, y se registraron las precipitaciones acumuladas. Se estimaron las variables de desarrollo vegetativo área foliar por árbol, área foliar por volumen de copa y el Índice de Área Foliar. Con los datos de cada variable en cada uno de los años se realizó un análisis de varianza de clasificación simple. Se calcularon variables de fructificación, producción y la eficiencia de la fructificación y la producción, se determinó la relación de éstas con las variables de desarrollo vegetativo a través de un Análisis de Correlaciones Canónicas. Los resultados muestran que el desarrollo vegetativo se corresponde con el comportamiento de las precipitaciones acumuladas anuales, cuando éstas aumentan, el desarrollo vegetativo es superior. El área foliar se relaciona directamente con la fructificación y la producción en ambos cultivares. El aumento del área foliar por árbol y la disminución del área foliar por volumen de copa, contribuyeron fundamentalmente al incremento de la fructificación (número de frutos por árbol) y la producción (kg de frutos por árbol).

Palabras clave: *Citrus sinensis*, superficie foliar, fructificación, producción vegetal

INTRODUCTION

Citrus fruits have a high importance from an economic and nutritional standpoint.

In the world 8,7 million hectares are dedicated to its cultivation and production amount to 122,3 million tones, of which 56,4 % are oranges[A].

[1] Instituto de Investigaciones en Fruticultura Tropical, La Habana, Cuba.
[2] Instituto Nacional de Ciencias Agrícolas (INCA), gaveta postal 1, San José de las Lajas, Mayabeque, Cuba, CP 32700.
✉ guillermo@inca.edu.cu; guillermo@enet.cu

[A]FAO. *FAO Statistical Yearbook 2013. Word food and agriculture*. Roma: FAO, 2013. 289 p. ISBN 978-92-5-107396-4.

In Cuba, citrus occupy 29,3 thousand hectares, with a production of 203,7 thousand tons, mainly oranges (46,1 %)[B].

Although the cultivated area and production have grown in recent years for different causes, mainly pest and disease impact, researches are continuing to develop the scientific and technical basis under new circumstances of the sector.

In this context, the study of vegetative development, behavior and yield components factors involved in them is important for the differentiated handling of cultivars by the application of appropriate planting, nutrition, phytosanitary defense, watering and pruning technologies in different edaphoclimatic conditions.

It is known that edaphoclimatic conditions influence the development of citrus trees. For example, the issuance of vegetative flows, plantations without irrigation is regulated by the occurrence of wet and dry periods (1, 2, 3). These flows vegetative growth or sprouting, are responsible for branch growth and increased leaf area of trees (4).

Therefore, the behavior of vegetative budding play a key role in maintaining an adequate balance between vegetative and reproductive structures, very important aspect for producing fruits and growth (5). Leaves produce and export photoassimilates to the rest of the tree and are known as sources, while non-photosynthetic organs (fruits and roots) are known as sinkholes (6). The leaf-fruit ratio is dependent on many factors such as species, variety, phytotechnical practices and soil and climate conditions (7, 8).

To compare the potential productivity of the top in citrus plantation systems, they were used vegetative development variables as the leaf area per tree and the leaf area index (LAI). The latter is defined as ratio of a leaf area and the soil surface area occupied by a tree[C, D] also it is used to model plant processes (9) and as an indicator of photosynthetic activity, by its relation to the sunlight interception (7). LAI also combined with climatic variables, has been used to calculate daily volumes of water needed to irrigate the crop in some agroecosystems (10).

[B]ONEI. *Anuario Estadístico de Cuba 2012. Edición 2013* [en línea]. Cuba: ONEI, 2 de julio 2013 [Consulta: 24 de septiembre 2013]. Disponible en: http://www.one.cu/aec2012/esp/20080618index.htm.

[C]Fischer, G. *La relación hoja/fruto en especies frutícolas*. En: IV Congreso Colombiano de Horticultura: 2011, 17-18 pp. Noviembre: Palmira, Colombia. Memorias IV Congreso Colombiano de Horticultura. Colombia: SCCH, 2011. pp. 40-53.

[D]Tucker, D. P.; T. A. Wheaton y R. P. Murano. *Citrus tree spacing*. Series of the Horticultural Sciences [Fact Sheet, HS-143] Univ. Fla., Florida, 1994. 10 pp.

However, little information exists about interrelationship studies between groups of vegetative and reproductive development variables in citrus Vegetative growth behavior and its relationship with fruiting processes, production and efficiency in oranges grown in Contramaestre citrus agroecosystem in the eastern region of Cuba, it is not known.

The study aim is to characterize the vegetative development of Valencia Late' and `Washington Navel` orange cultivars ` and determine the relationship of vegetative development to fruiting and production besides , production and fruiting efficiency.

MATERIALS AND METHODS

The experience was developed in the period 2000-2002, sweet orange trees were used [*Citrus sinensis* (L.) Osbeck], 'Valencia Late' (VL) and 'Washington Navel' cultivars (W.N.), 30-33 years age, grafted on sour orange (*Citrus aurantium* L.) and planted at a distance of 4 x 8 m.

The experimental plots are located at 20 ° 18'56 '' North Latitude; 76 ° 16'22 '' West Longitude (VL), and 20 ° 19'56 '' North Latitude; 76 ° 17'32 '' West Longitude (WN), in production areas without irrigation, belonging to the Citrus Company "América Libre" municipality Contramaestre, Santiago de Cuba province.

The soil is classified as calcic fluffy brown soil (11). The agronomic management of plantations was made according to the technological scheme of the company during this period and accumulated precipitation (Pr; mm) were recorded in pluviometers located 300 m of the experimental plots.

Characterization of vegetative development

The vegetative development was characterized in the four central trees of a selected plot in each cultivar and constituted by 16 trees (four per row). During each of the three budding waves per year, leaf number were evaluated per the surface top, dimensions of trees and vegetative development variables (12) were estimated.

Leaf number per top surface was recorded [*Ln*; leaves (m² top)$^{-1}$] through a frame of 0,25 m placed to 1,5 m of the tree height by cardinal points of the top and the five leaves leaf surface was determined (cm^2 leaf)$^{-1}$ for each top cardinal point, using a digital planimeter *Delta T-Device (UK*).

Moreover, tree height dimensions (*TH*; m), height from the ground to the base of the top (m S) and top diameter in two directions, North-South (NS) and East-West (EW) were evaluated, which was determined as maximum horizontal diameter (Dp_{N-S} and Dp_{E-W}) and horizontal diameter to 1,5 m of tree height (Dm_{N-S} and Dm_{E-W}) using a ruler in mm and a length of 7 m. Then, the average leaf area (*Sp* $cm^2.leaf^{-1}$), canopy height (H, m) *H = AT-S*, the maximum horizontal radius of the top (*Rp*; m) $Rp = [(Dp_{N-S} + Dp_{E-W})/2]/2$, the horizontal radius of the crown to 1,5 m of the tree height (*Rm*; m) $Rm = [(Dm_{N-S} + DM_{E-W})/2]/2$ and the volume of the top (*Vc*; m3) $Vc = 2{,}0944\ Rp^2\ H$ were estimated.

In each budding wave, vegetative growth variables were estimated: leaf area per tree (*At*, $m^2.top^{-1}$) $At = (Vc\ Sp\ Nh)/Rm$, leaf area per canopy volume [*Av*, m^2. (m^3 top)$^{-1}$ $Av = (Sp\ Nh)/Rm$ leaf area per tree;.] and leaf area index $LAI = (0.667\ Sp\ Nh\ H)/Rm$. The outcome in vegetative development variables is the annual cumulative sum of the three sprouting waves.

The data for each variable in each of the years were analyzed by a variance analysis of simple classification (p≤0,05).

Relationship of vegetative development with fruiting, production and fruiting and production efficiency

Fruiting variables, production and fruiting and production efficiency (12) were calculated. Fruiting variables and its efficiency were number of fruit per tree $Ft = 2{,}1[(Rp^2\ H)/Rm]$, number of fruits per cubic meter of top tree $Fv = F/Rm$; where *F* is the amount of fruits (m^2 top)$^{-1}$ at the end of the fruit setting period and was recorded through a frame of 0,25 m placed to 1,5 m of tree height by top cardinal points and leaf square meters per fruit $Rhf = 0{,}0001\ [(Sp\ Nh)/F]$.

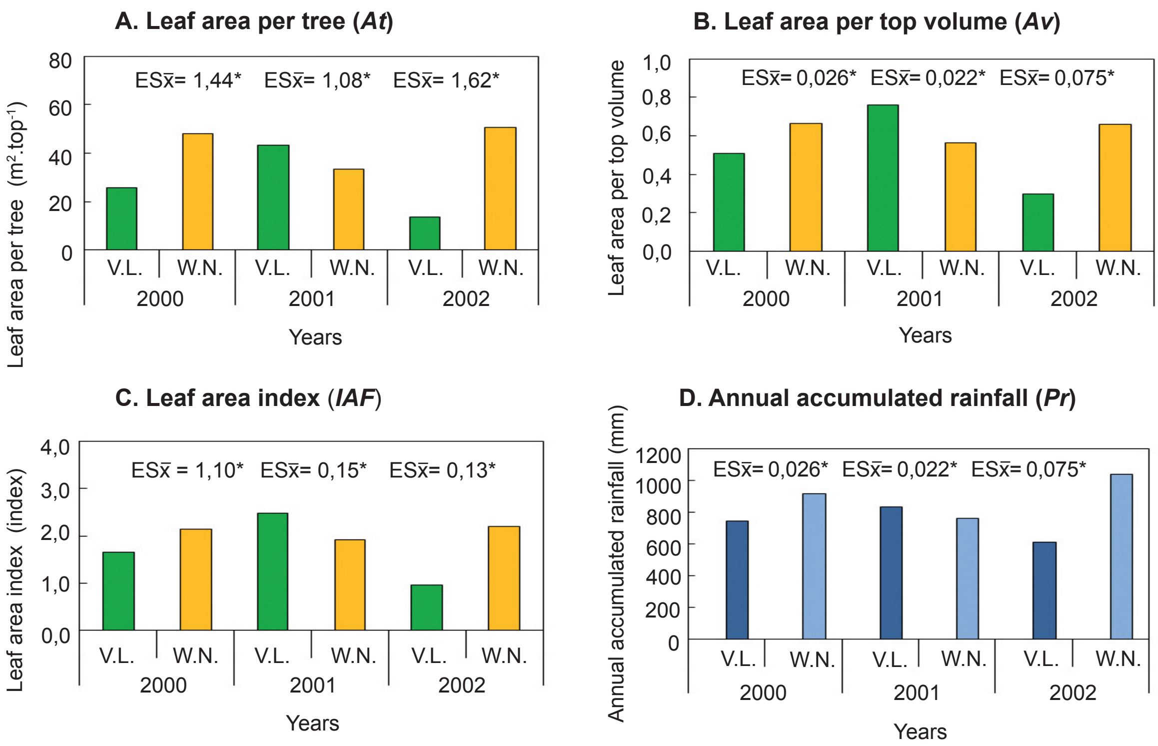
Production and its efficiency variables were: kilograms of fruit per tree $Mt = 0{,}021 Mf\ F\ [(Rp_2 H)/Rm]$; where *Mf* is the average mass of five ripe fruits per tree, harvested in the months of October ('Washington Navel') and December ('Valencia Late'), kilograms of fruit per cubic meter of top tree $Mv = (Mf\ F)/(1000\ Rm)$ and leaf square meters per kilogram of fruit $Rhm = 0{,}1\ [(Sp\ Nh)/Mf\ F)]$.

To determine the relationship between vegetative development variables to fruiting, production and efficiency, the multivariate method of Canonical Correlation Analysis, after standardization of data, (13) was used. Statistical analyzes were performed using the STATGRAPHICS® Plus software, version 5.1.

RESULTS AND DISCUSSION

Characterization of vegetative development

It is noted, generally in each cultivar, correspondence among the magnitudes of vegetative development variables, leaf area per tree (Figure A), leaf area per canopy volume (Figure B) and leaf area index (Figure C) with annual accumulated rainfall (Figure D).



† Annual accumulated values of the three waves of sprout
*Signification for p≤0,05 according to variance analysis, n=4

Behavior of vegetative development variables† (A, B, C) and accumulated rainfall (D) in 'Valencia Late' (V. L.) and 'Washington Navel' (W. N.) oranges

These variables showed higher values to the extent that cumulative rainfall was more abundant.

Moreover, the estimated values of LAI average over the three years of study were 1,7 ('Valencia Late') and 2,0 ('Washington Navel'). These values are lower than those reported in Florida, United States (14), which ranged from 3,9 to 5,1 and in Ceiba del Agua, Cuba[E] with values between 2,5 to 3,6; all *Citrus sinensis (L)* Osbeck*,* plantations with similar planting distances but with irrigation.

In effect, informed and estimated IAF values are very different; however, given the average leaf area for both cultivars in the Contramaestre agroecosystem presented some similar values to reports from the above, in Ceiba del Agua and Florida plantations by author. This fact points to the apparent differences between of LAI shown among agroecosystems are mainly due to leaf number per top surface (NL) (data not shown).

Low values of NL quantified in this agroecosystem could be associated to two factors, on one hand,dry land conditions in which the crop is developed and on the other, to the cultural care, especially nutrition made with nitrogen (N), where doses tree 0,25-030 kg N yr^{-1} were lower than the estimated needs, and also with respect to those used in agro comparison.

Both factors are closely related to vegetative growth and probably contributed to the shown variation. In this regard, it has been reported that water stress periods cause effects on vegetative growth of citrus as senescence and abscission of leaves (15), so optimize nutrition with N in citrus trees needed to regulate the vegetative growth (16).

[E]Pozo, L. V. Comunicación personal, 2007. Citrus Research and Education Center. UFLA. Lake Alfred, Florida, EE. UU.

The LAI is an indicator of photosynthetic activity (7). It also constitutes the physiological variable that influences the differentiation of America's citrus regions which corresponding the lowest values to plantations without irrigation and warmer climates (17).

Relationship between vegetative development with fruiting, production and efficiency of fruiting and production

The Canonical Correlation Analysis showed the group influence of vegetative development variables on variable groups of fruiting, fruiting production efficiency and production in both cultivars (Table IA and B; Table IIA and B). According to this analysis, the pair of canonical variables (U_1-V_1) accounted for most association between physiological variables groups with a high canonical correlation coefficient.

Among plant development variables that influence on fruiting and efficiency in 'Valencia Late' (Table IA), are the leaf area per tree *(At)* and leaf area index *(LAI)*. When both increase volume and leaf canopy *(Av)* decreases, area cause an increase in the number of fruits per tree (Ft) and a decrease in fruit number per m^3 of canopy *(Fv*). While in 'Washington Navel' (Table IB) a similar influence was observed, although this cultivar the *LAI* did not influence decisively.

Moreover, considering the influence of vegetative development variables on production and efficiency, both 'Valencia Late' (Table II A) and 'Washington Navel' (Table II B) it was found that with increasing *At* and *Av* decreases, induce an increase in kg of fruit per tree *(Mt)* and a kg decrease of fruit per m^3 of canopy *(Mv)*.

Table I. Canonical Correlation Analysis between vegetative development variables† (x_1, x_2, x_3) and fruition and its efficiency†† (y^1, y^2, y^3), in two orange cultivar [*Citrus sinensis* (L.) Osbeck]

U_1	Coeficient	V_1	Coeficient	Canonical correlation §
A) 'Valencia Late' cultivar				
x_1. Leaf area per tree top (*At*)	-1,69	y_1. Number of fruits per tree (*Ft*)	-1,23	
x_2. Leaf area index (*LAI*)	-1,91	y_2. Number of fruits per m^3 of top tree (*Fv*)	1,87	0,99**
x_3. Leaf area per tree top volume (*Av*)	3,82	y_3. m^2 of leaf per fruit (*Rhf*)	-0,18	
B) 'Washington Navel' cultivar				
x_1. Leaf area per tree top (*At*)	-1,23	y_1. Number of fruit per tree (*Ft*)	-2,09	0,96**
x_2. Leaf area index (*LAI*)	0,25	y_2. Number of fruits per m^3 of top tree (*Fv*)	2,15	
x_3. Leaf area per tree top volume (Av)	0,63	y_3. m^2 of leaf per fruit (*Rhf*)	-0,30	

§ Signification for p≤0,01; n=12

† Sum of accumulated values of sprouting in 2000 and the sprouting of February-March, 2001 and sum of accumulated values of sprouting of 2001 and sprouting of February-March 2002.

†† Estimated values when setting fruit period ended of April-May, 2001 and 2002

Tabla II. Análisis de correlaciones canónicas entre variables de desarrollo vegetativo† (x_1, x_2, x_3) y de producción†† y su eficiencia (z_1, z_2, z_3) en dos cultivares de naranjo [*Citrus sinensis* (L.) Osbeck].

U_1	Coeficient	V_1	Coeficient	Canonical correlation§
A) 'Valencia Late' cultivar				
x_1. Leaf area per tree top (*At*)	2,09	z_1. kg of fruit per tree (*Mt*)	1,27	
x_2. Leaf area index (*LAI*)	0,52	z_2. kg of fruit per m³ of tree top (*Mv*)	-1,65	0,99**
x_3. Leaf area per tree top volume (*Av*)	-2,50	z_3. m² of leaf per kg of fruits(*Rhm*)	0,34	
B) 'Washington Navel' cultivar				
x_1. Leaf area per tree top (*At*)	1,01	z_1. kg of fruit per tree (*Mt*)	1,70	
x_2. Leaf area index (*LAI*)	0,49	z_2. kg of fruit per m³ of tree top (*Mv*)	-1,79	0,97**
x_3. Leaf area per tree top volume (*Av*)	-1,12	z_3. m² of leaf per kg of fruits(*Rhm*)	0,06	

§ Signification for p≤0,01; n=12
† Annual accumulated values of sproutings in 2000,2001 and 2002.
†† Estimated values when the harvest ended in October (`Washington Navel`) and December (`Valencia Late`) years 2000, 2001 and 2002.

This dependence was not known in the Contramaestre citrus agroecosystem and shows the specific relationship of leaf area per tree, as well as canopy volume with production and efficiency variables. From a practical standpoint, it can handle agronomic crop aspects such as planting density, pruning and fertilization, influencing vegetative growth variables as *At* and *Av*.

Leaf area is related to the fruition and production in both cultivars. The increase in leaf area per tree and leaf area per canopy volume decrease, mainly contributed to the increase of fruiting (number of fruit per tree) and production (kg of fruit per tree).

The direct relationship of leaf area with fruit number and kilograms of fruit (all defined by tree), was associated with the leaf number per surface of the top, to the leaf surface, and the development of the canopy, expressed by volume.

In this regard, leaf area, has a direct relationship with the photosynthetic capacity (18), which affects the supply of photoassimilates (19). In fruit (7,.20) has shown a direct relationship between leaf area per tree and production.

In study conditions in plantations without irrigation, a leaf number decrease of abscission, or other factors could reduce the sunlight interception by the top tree, reducing the amount of photoassimilates produced and consequently the biological and agricultural productivity is affected culture (14, 21).

Moreover, the inverse relationship of leaf area per top volume with the fruit number per tree and kilograms of fruit per tree can be associated with the number of leaves per top surface *(NL)*. An increase of *NL* means vegetative growth more detrimental to reproductive, suggesting that bud differentiation was favourable to the vegetative and therefore decreased the amount of produced flowers, setting fruit and yield per tree.

According to the results, the Canonical Correlation Analysis is an appropriate statistical tool for the analysis of multiple variables and facilitates the study of the interrelationships between groups of dependent and independent variables, as has been shown in other studies (22).

CONCLUSIONS

- ♦ The vegetative growth of orange 'Valencia Late' and 'Washington Navel' in the Contramestre citrus agroecosystem, corresponds to the behavior of the annual accumulated rainfall, when they rise, the vegetative development is superior.
- ♦ Leaf area is related to the fruition and production in both cultivars. The increase in leaf area per tree and reduced leaf area per canopy volume, mainly contributed to the increase of fruiting (number of fruit per tree) and production (kg of fruit per tree).

BIBLIOGRAPHY

1. León, M.; Pérez, M.; Soto, E.; Avilán, L. y Gutiérrez, M. A. Fenología de la naranja 'Valencia' sobre tres patrones en Yumare, estado Yaracuy, Venezuela. *Revista Científica UDO Agrícola*, 2009, vol. 9, no. 2, pp. 347-355. ISSN: 1317-9152.
2. Rivas, F.; Bemal, R.; Bertalmío, A. ; Buenahora, J.; Goñi, C.; Lado, J.; Pérez, E.; Otero, A. y Mara, H. La Citricultura Bajo Estrés. Un Enfoque Integral. *Revista INIA*, 2009, no. 17, pp. 68-72. ISSN: 0718-5820.
3. Orduz, J.; Hernán, J. y Fischer, G. Comportamiento fenológico de la mandarina 'Arrayana' en el piedemonte del meta, Colombia. *Agronomía Colombiana*, 2010, vol. 28, no. 1, pp. 63-70. ISSN: 0120-9965.
4. Ramos, R.; Vasconcelos, R.; Caruso, E. y Silverio, R. Seasonal variation in vegetative growth of Hamlin sweet orange grafted on Swingle citrumelo plants, in Limeira, São Paulo State. *Acta Scientiarum. Agronomy*, 2010, vol. 32, no. 3, pp. 539-545. ISSN: 1807-8621.
5. Park, S. J. Dry weight and carbohydrate distribution in different tree parts as affected by various fruit-loads of young persimmon and their effect on new growth in the next season. *Sci. Hortic.*, 2011, vol. 130, pp. 732-736. ISSN: 0304-4238.

6. Marschner, P. (ed.). *Marschner's mineral nutrition of higher plants*. 3th ed. Boston: Elsevier/Academic Press 2012. 643 pp. ISBN: 0123849055, 9780123849052.
7. Fischer, G.; Almanza-Merchán, P. J. y Ramírez, F. Relación fuente-vertedero en especies frutales. Una revisión. *Rev. Colomb. Cienc. Hortic*., 2012, vol. 6, no. 2, pp. 238-253. ISSN: 2011-2173.
8. Casierra-Posada, F. y Fischer, G. Poda de árboles frutales. En: Fischer, G. (ed.). Manual para el cultivo de frutales en el trópico. 1ra ed. Bogotá: Produmedios, 2012. pp. 169-185.
9. Velazco, S.; Champo, O.; España, M. y Baret, F. Estimación del índice de área foliar en la reserva de la biosfera Mariposa Monarca. *Revista Fitotecnia Mexicana*, 2010, vol. 33, no. 2. pp. 169-174. ISSN: 0187-7380.
10. Pereira, A. B.; Villa, N. A. y Alfaro, A. T. Water requirements of citrus and Apple trees affected by leaf area and solar energy. *Rev. Bras. Frut.*, 2009, vol. 31, no. 3, pp. 671-679. ISSN: 0100-2945.
11. Hernández, A.; Pérez, J. M.; Bosch, D. y Rivero, L. Nueva Versión de la Clasificación Genética de los Suelos de Cuba. La Habana: AGRINFOR. 1999. 64 pp.
12. Pozo, L. V.; Lima, H.; Pérez, M. C. y Noriega, C. Metodología para la evaluación de números de flores, frutos y área foliar totales en árboles cítricos. *Citrifrut*, 1994, vol. 12, no. 1-2, pp. 12-14. ISSN: 1607-5072.
13. Varela, M. Análisis Multivariado de Datos. Aplicación a las Ciencias Agrícolas. La Habana: Ediciones INCA, 1998. 58 pp. ISBN: 959-7023-04-0.
14. Tan Li, K.; Syvertsen, J. P. y Dunlop, J. Defoliation after harvest with a trunk shaker does not affect canopy light interception in orange trees. *Proc. Fla. State Hort. Soc*., 2006, vol. 119, pp. 187-189. ISSN: 0097-1219.
15. Gómez-Cadenas, A.; Tadeo, F.; Talón, M. y Primo-Millo, E. Leaf abscission induced by ethylene in water stressed intact seedling of Cleopatra mandarin requires previous abscisic acid accumulation in roots. *Plant Physiol*., 1996, no. 12, pp. 401-408. ISSN: 0032-0889.
16. Phadung, T.; Krisanapook, K. y Phavaphutanon, L. Paclobutrazol, water stress and nitrogen induced flowering in `Khao Nam Phueng` Pummelo. *Kasetsart J. (Nat. Sci)*, 2011, vol. 45, pp. 189-200. ISSN: 0075-5192.
17. RIAC. Bioclimatología. Una herramienta para el desarrollo del cultivo de los cítricos en Cuba y en las Américas. *Carta Circular*, 2006, no. 25, pp. 2-8.
18. Toebe, M.; Brum, B. ; Lopes, S. J. y Filho, A. C. Estimate leaf area of Crambe abyssinica for leaf discs and digital photos. *Ciência Rural*, 2010, vol. 40, no. 2, pp. 475-478. ISSN: 0103-8478.
19. Mahouachi, J.; Iglesias, D. J.; Agustí, M. y Talón, M. Delay of early fruitlet abscission by branch girdling in citrus coincides with previous increases in carbohydrate and gibberellin concentrations. *Plant Growth Regul*., 2009, vol. 58, no. 1, pp. 15-23. ISSN: 0167-6903.
20. Agustí, M. Fruticultura. Madrid: Editorial Mundi-Prensa, 2010. 507 pp. ISBN: 978-84-8476-398-7.
21. Lopes, L. F.; Vasconcelos, R.; Ferraz de Oliveira, R. y Caruso, E. Variation of sap flow density and leaf water potential in the east and west side of the canopy of 'Valencia' sweet orange plant. *Rev. Bras. Frutic*., 2010, vol. 32, no. 1, pp. 35-46. ISSN: 0100-2945.
22. Nave, R.; Silveira, C. G. y Gonçalves, C. Canonical correlations among chemical, physical and morphological characteristics of Xaraés palisadegrass under rotational grazing. *Sci. Agric*., 2009, vol. 66, no. 2, pp. 270-275. ISSN: 0103-9016.

Received: October 4th, 2013
Accepted: June 19th, 2014