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Assessing Budsports of 'Valencia' Sweet Orange (*Citrus sinensis* (L.) Osbeck) for Desirable Characteristics

DR. DIMITRIOS KOTSIAS

Abstract

Three mutant clones of 'Valencia' orange were compared to the standard cultivar. All selections and the source cultivar were grafted onto *Citrus aurantium* L. rootstock and assessed for yield, vigor, fruit quality and other morphological characteristics for a period of four years.

Two clones (A and B) displayed significant improvements over the standard Valencia cultivar. Over 4 consecutive years, major characteristics such as yield, fruit morphology and juice quality were found to be better in clones A and B. Clones A and B gave a greater yield per tree and greater mean fruit weight, while clone A gave a higher endocarp/pericarp ratio and increased endocarp weight. Clones A and B contained more juice per fruit, and higher total soluble solids and vitamin C compared to the standard 'Valencia' clone. Clone B ripened at the same period as main cultivar, while clone A ripened 30-35 days later and clone C 30 days earlier

The improved characteristics and altered ripening time of clones A and B warrant propagation of this plant material and broader testing on a commercial scale.

[1]Agricultural University of Athens, 75 Iera Odos, 11855, Athens, Greece.

Introduction

'Valencia' sweet orange was originally discovered in the USA (1) and was exported to Spain where it received its name through extensive cultivation in the region known as Valencia (2, 3). The characteristics of late ripening, good flavor, high juice yield, and good quality on the tree for long periods make 'Valencia' excellent for juice production, and also good for fresh fruit. The trees are also vigorous and very widely adapted, making 'Valencia' one of the most important sweet orange cultivars in many citrus growing areas.

Despite the many good characteristics of 'Valencia,' there are also some disadvantages, the most important of which are modest productivity, a tendency to irregular bearing, undesirable color changes during the summer (from orange to green) and fruit granulation (vesicle drying) later in the season. In addition, improvement of fruit size and increased juice content would be beneficial in some markets, and identifying clones with different periods of maturation may permit growers to avoid environmental risks in some seasons and broaden the period in which high-quality 'Valencia' fruit can be sold.

Merle, Chapot and Huet report that 'Valencia' is genetically unstable and frequently produces mutations or budsports which can be readily observed on trees (4). Such budsports have been assessed for potential improved characteristics and have been the source of many clonal selections (such as Cutter, Frost, Campbell,and Olinda) which have been released in California and cultivated around the world (5, 6, 7). This process continues with the new cultivars Armstrong and Perry identified in California, Muden in S. Africa, Seedless Valencia in Australia and Ksiri in Morocco all derived from bud mutant selections of 'Valencia' (2).

Despite the many selections which have been made in 'Valencia' orange, there is still a need for improved selections and the search for new and better 'Valencia' strains continues. Shoots of some 'Valencia' trees grown in Ag. Saranta and Delvino in Albania, showed interesting morphological alterations in shoots and fruit, fruit weight, juice quality and ripening time compared to the original 'Valencia' selection. The purpose of this study was to find out whether these bud mutations have stable characteristics, different from and better than those of the main cultivar. Thus, this investigation concentrated on characteristics such as high and stable yield, juice quality, fruit weight, fruit appearance and morphology, cold and disease tolerance and time of ripening. Clones with desirable and improved characteristics would then be propagated for further assessment in commercial farms and may ultimately increase farm profitability.

Materials and Methods

The search for possible bud sports was conducted in an orchard of the former agricultural company Stiari in Ag. Saranta of Albania with a total area of 6.0 ha containing 2400 orange trees. These trees were planted using budwood obtained from Italy. To identify shoots which exhibit morphological differences from standard 'Valencia' trees, observations were made twice a year for three consecutive years (1976-1978) on 600 trees of the above orchard. The first observations were made during spring and included: anthesis (flowering), production (light, medium, heavy); shoot vigor; color and morphology of leaves and canopy; pest and disease status. The second observations were made during fruit ripening and included external morphological characteristics of tree and fruit as well as ripening period and pest and disease status.

From trees identified as morphological distinct from standard 'Valencia,' three trees (putative budsport clones A, B and C) with clear and strong differences were identified for further investigation as follows. Other trees with budsports were also identified but they were not included in this research because their characteristics were not important or they were very similar to those of 'Valencia.' Buds from current shoots of the budsport trees and standard 'Valencia' were taken and budded on sour orange rootstock in 1978. Virus status

Table 1. Leaf length and width of the 'Valencia' orange and selected bud sports (mean value of four years).

'Valencia' clones	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Length:width Ratio
Valencia	11.00 c	4.80 bc	1.66 a	2.29:1 b
Clone A	13.20 a	5.20 a	0.98 c	2.53:1 a
Clone B	12.44 b	4.78 b	1.40 b	2.60:1 a
Clone C	10.52 d	3.95 c	0.88 c	2.66:1 a

Duncan test was used for the comparison of means. Level of significant difference p = 0.05.

of the trees was not examined but no virus symptoms appeared on them. Three years after budding the young trees were transplanted at 5 x 5 m spacing in a randomized complete block design experiment with 3 blocks and three replicates (trees)/clone in each block including the standard 'Valencia' "parent" selection. The orchard soil is of medium texture (sandy-clay) and a pH 6.8-7.4. Trees were irrigated during the summer and pruned each year. Annual fertilizer applications of 0.48 kg P, 1.0 kg of N and 0.70 kg of K per tree were made and sprays against common pests and diseases were also carried out.

In 1990 when the trees began to produce a good crop and the morphological characteristics of trees and fruits stabilized, a comparative study of the following characteristics was made for a period of four consecutive years (1990-1993):

1. Vigor general growth and tree canopy morphology.

Canopy dimensions were measured (height, diameter) and the canopy shape was described. Canopy volume was estimated by using the equation of Wutscher and Schull (8) V = (W1 x W2 x H)/4. V = volume (m^3), W1, W2 the two canopy diameters (m). H = Tree height (m).

2. Leaf size, shape, color and petiole size.

Random samples of 40 leaves per/tree (all the experimental trees were used) were taken from one year old shoots. Leaf width, leaf length and petiole length were measured and expressed in cm.

3. Yield level.

Total fruit weight was measured for each tree. The weight of fallen fruit in good condition was added to the above.

4. Fruit weight (g) and other fruit characteristics.

Twenty fruit from each experimental tree were randomly selected and the following measurements made: average fruit weight, peel and flesh weight, number of segments and seeds, fruit morphology, juice volume. The harvest occurred on the dates when the fruits were consider to be ripen (when the colour of fruits change, from green to orange/yellow and had taken place over 100% of the fruit surface and in 80% of the tree's fruit).

5. Juice characteristics.

Twenty fruit from each experimental tree were randomly selected and the following measurements carried out:

(a) *Determination of acidity (10%).*

The total volumetric acidity of the juice was determined by titration with 0.1 N NaOH and expressed as % citric acid.

(b) *Determination of vitamin C (mg/100 ml).*

The chemical method for this determination is based on the reduction of colored 2,6 dichorophenol indophenol to the colorless form.

Table 2. The annual yield of the 'Valencia' orange and selected bud sports. (mean value of four years).

'Valencia' clones	Kg/tree	Canopy volume (m^3)	Productivity factor (Kg/m^3)
Valencia	37.75 c	8.52 b	4.52 b
Clone A	68.50 a	11.95 a	5.77 a
CloneB	44.16 b	9.19 b	4.86 b
Clone C	29.91 d	6.59 c	4.60 b

Duncan test was used for the comparison of means. Level of significant difference p = 0.05.

Table 3. Fruit weight and other characteristics of the 'Valencia' orange and selected bud sports (mean value of four years).

'Valencia' clones	Fruit weight (g)	Endocarp weight (g)	Peel weight (g)	Peel width (mm)	Endocarp:peel ratio	Ripening date	Fruit shape
Valencia	158.7 c	117.4 b	41.25 c	4.17 c	2.84:1 a	February10-15	Oblate-sph.
Clone A	226.8 a	168.0 a	55.58 a	5.09 a	2.88:1 a	March 15-20	Sph.-oblate
Clone B	177.2 b	118.9 b	49.91 b	4.56 b	2.38:1 b	February 10-15	Sph.-oblate
Clone C	124.7 d	93.00 c	31.83 d	3.72 d	2.92:1 a	January 10-15	spherical

Duncan test was used for the comparison of means. Level of significant difference p = 0.05.

(c) *Total soluble solids.*

Total soluble solids mostly in the form of sugars, were determined using a hand refractometer and expressed in °Brix.

(d) *Total dry weight of fruit (%).*

Fruit fresh weight was measured and fruit was then placed in an oven at 70°C until there was no further weight reduction. The oven-dry weight was then expressed as % of fresh weight.

6. Ripening period.

Observations were made for each tree variety and clone. Fruits were considered to be ripe when the fruit color change, from green to orange/yellow, had taken place over 100% of the fruit surface and in 80% of the tree's fruit.

Results and Discussion

1. Tree dimensions and morphological characteristics

Morphologically, clones A, B and C were distinguished from the trees of standard 'Valencia' in most of the parameters measured. Clone A had the greatest canopy height and diameters among the other clones and the main cultivar, while clone C had the least (data not shown). These results indicate that clone A is more vigorous than the standard Valencia cultivar and clone C is less vigorous than the main cultivar and the other clones. Some differences are also noticeable in the shape and orientation of branches between the clones and standard Valencia trees. Clone A had cup shape while 'Valencia' and clones B, C cup-spherical. The orientation of branches was upwards in clones A and B, down-wards in clone C while 'Valencia' had sideways-upwards.

Similar to the canopy, leaf dimensions were greatest in clone A and least in clone C (Table 1). However, petiole length was smaller in clones A and C compare to clone B and standard 'Valencia' trees, while the parent cultivar had longer petioles than any of the mutant clones. Clone A had large deep green leaves while clone C had small leaves of a light green color. It appears that a separation of the three clones from standard 'Valencia' is possible by using the above morphological characteristics

2. Production

(a) *Yield.*

Table 2 shows that clone A had the greatest yield per tree, which was much higher than that of 'Valencia.' Clone B also had higher yield than standard 'Valencia'

Table 4. Qualitative characteristics of fruit of the 'Valencia' orange and selected bud sports (mean value of four years).

'Valencia' clones	Juice content per fruit (ml)	Acidity %	Total soluble solid content °Brix	Vitamin C mg/100 ml	Dry weight %
Valencia	59.25 c	1.61 b	6.20 b	62.33 c	10.03 b
Clone A	94.58 a	1.47 c	6.58 a	69.84 a	10.20 a
Clone B	71.91 b	1.62 b	6.26 b	66.39 b	10.04 b
Clone C	47.00 d	1.77 a	5.93 c	59.85 c	10.08 b

Duncan test was for the comparison of means. Level of significant difference p = 0.05.

though less than clone A, while clone C had the least yield (less than standard 'Valencia'). Clone A had also the greatest canopy volume and productivity factor amongst the other clones and standard 'Valencia.' The superiority of clone A in yield and productivity is obvious from these results and makes further investigation of clone A very important.

(b) *Fruit weight.*

The high average fruit weight of clone A (greater than the standard 'Valencia' by 68 g , Table 3) is one of the main factors contributing to the superior yield of this clone. Clone B had also higher weight than 'Valencia,' while clone C had the least weight. Similar results were observed for endocarp weight that is a very important characteristic for the customers of orange fruit.

(c) *Other fruit characteristics*

Peel weight and thickness of fruit from bud sports were significantly different from standard 'Valencia.' Significant differences also existed between clones, with clone A having the highest value and clone C the least (Table 3). However, the ratio of endocarp/peel weight, an important characteristic for citrus, was similar for 'Valencia' and clones A and C. Clone B had the lowest ratio. The number of seeds per fruit was 0-4 for clones A and B and 35 seeds per fruit in clone C. The number of segments was very similar for all the clones and standard 'Valencia' orange (9-11).

The difference in yield between clone A and other clones including 'Valencia,' in this study, is much higher than the difference between 'Valencia' and five other clones studied by Rouse et al. (9). This high difference can be attributed to the superiority of this budsport that gave a much higher canopy volume, fruit weight and consequently productivity factor (Tables 2 and 3). Despite the differences in productivity (yield/tree) between the clones study in Albania and those studied in Texas (9) the canopy volumes and the productivity factors were very similar. The lower productivity of 'Valencia' in Albania might be attributed to the quite different soil and climatic conditions.

3. Quality characteristics of juice.

Clone A had the highest juice content in comparison with standard 'Valencia' and the other budsports, (Table 3). Clone B also had higher juice content than 'Valencia,' while clone C had the least.

In contrast, clone A was found to have the lowest acidity, with standard 'Valencia' cultivar having acidity similar to clone B, and clone C having the highest acidity.

The total soluble solid (t.s.s.) content, that is an important indicator of internal fruit quality, was greatest (6.58) in clone A. Clone B had the same t.s.s. content as standard 'Valencia,' while clone C had the least t.s.s. content. Similar to t.s.s. content, vitamin C content was highest in clone A (69.8 mg/100 ml), followed by clone B, while clone C and standard 'Valencia' were similar to each other but had less vitamin C than clones A and B. The total dry weight of fruit was significantly higher in clone A than standard 'Valencia' or clones B and C.

4. Ripening period.

It is interesting to note that clone A was found to be later ripening (30-35 days later than standard 'Valencia') and therefore frost damage to fruits, which is commonly observed in the cultivated areas of Ag. Saranta, can be avoided. Clone C was found to ripen one month earlier than 'Valencia.' Clone B ripened in the same period as standard 'Valencia.' The different ripening periods of clone A and C indicate the potential importance of altered ripening on extending markets of 'Valencia.'

5. Resistance to pests, diseases and low temperatures.

No differences between the clones were found as regards pest/disease resistance and cold tolerance. However, the standard 'Valencia' and tested budsports showed tolerance to the lowest temperatures experienced in the study (–8 °C).

No virus symptoms were observed on the experimental trees, however, if the clones were infected with different viruses, they may partly affected their perfor-

mance and might contribute to the observed responses.

6. Compatibility with the rootstock.

In no instance was there any incompatibility between the rootstock and the budsport clones or standard Valencia cultivar.

Conclusions

Important statistical differences were found between the three budsport clones and the standard Valencia cultivar. Clone A had superior yield, fruit size and weight, fruit juice content, total soluble solid and vitamin C content compared to standard 'Valencia' and the other clones. The later ripening of clone A (30-35 days later than 'Valencia') may also offer important commercial advantages. Clone B is also better than standard 'Valencia' in most of the characteristics studied while clone C has inferior characteristics with the exception of its earlier (30 days than 'Valencia') ripening.

The results, which were consistent over 4 years, indicate the identification of two interesting new budsports of 'Valencia' which may have significant commercial potential. Buds of clones A, B, and C may be obtained in small amounts by contacting the author at the indicated address.

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Apple Bud Dormancy Progression

One-year-old, ca. 500 mm long shoots of 'Golden Delicious' and 'Granny Smith' apple were selected randomly from commercial orchards in either Elgin (34°S, 305 m, ca. 900 chill units (CU) in 1995) or the Bokkeveld (33°S, 945 m, ca. 1500 CU in 1995) regions of the Western Cape, South Africa. Twenty shoots were harvested weekly from 29 March 1995 until 23 August 1995 and forced at a constant 25°C with continuous illumination until budburst was observed on four out of 20 shoots per bundle, i.e. days to 20% budburst. The progression of bud dormancy in Elgin differed from that observed in the Bokkeveld. Both cultivars reached maximum dormancy in the Bokkeveld before any considerable chilling accumulated (< 100 CU), but in Elgin, ca. 600 CU accumulated before a maximum was attained. In Elgin temperatures that normally promote chill requirement satisfaction enhanced dormancy. The chilling models used in this study were inadequate in considering climatic conditions involved in the entrance to bud dormancy—possible freezing temperatures or frost conditions. From Cook and Jacobs. 2000. J. Hort. Sci. & Biotech 75(2):233-236.