



## Preliminary selection of the orange cultivars using as female parents in diploids crosses and in triploidy program

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### Abstract

The genetic improvement of orange trees constitutes the promising route of varietal diversification. In addition, the use of spontaneous triploidy enables to produce new seedless fruit varieties. Thus, the process of crossbreeding and rescuing immature embryos constitute the basic steps for the success of this method. As a matter of consequence, this article is aimed at selecting the best female parents of orange trees that will be used in a crossbreeding program. 16 varieties of orange grown from the citrus collection of El Menzeh INRA field of Kenitra were subjected to a varietal evaluation during two years of study. The number of seeds per fruit is the main criterion of selection because it determines the new hybrids. Similarly, fruit quality criteria were studied. The variables under study are significant for all varieties of orange trees. Indeed, the sugar content varied from 9 to 12 for the sweetest oranges: *Tarocco* and *Hamlin*. Similarly the acidity oscillated from 0.81 to 2.34 with a low content for the varieties *Thomson* and *Robertson*. In addition, the average weight of the fruit fluctuated from 87 to 207 g with relatively high values for the *Tarocco* variety. Also, the number of seeds per fruit varied from 0 to 12. (*Parson Brown* and *Pineapple*). In addition to the good quality of the fruit, the *Pineapple* and *Parson Brown* varieties will be able to serve the crossbreeding program as female parents since they represent a great power to be pollinated.

**Keywords:** citrus, orange, fruit quality, cross breeding, triploidy

### 1. Introduction

Morocco has very good climatic and ecological conditions which improve the potential of producing many varieties of fruits and vegetables, and in particular the cultivation of citrus fruits. Indeed, this citrus sector has recently undergone an important development thanks to the efforts made within the framework of Green Morocco Plan. The production of citrus fruit has increased from 1.4 MT in 2008 to 2.36 MT in 2016. This plan has a tendency to produce 2.9 MT by 2020 <sup>[1, 2]</sup>. Similarly, it is aimed at producing 962,250 tonnes of orange. However, 89% of this production is dominated by the varieties *Valencia Late* and *Washington Navel* <sup>[3]</sup>. As a result, varietal diversification, in terms of quality and extension of the production period, is the main objective of improving this breeding program. *Citrus sinensis* (L.) Osbeck, the most widely grown orange in the world, is an interspecific hybrid rather than a true species <sup>[4]</sup>, derived from grapefruit (*Citrus maxima*) and mandarin (*Citrus reticulata*) <sup>[5]</sup>. Biological constraints are an obstacle to the genetic improvement of orange trees, namely polyembryony, gametes sterility, genetic incompatibility, length of juvenile phase and strong heterozygosity <sup>[6]</sup>. Indeed, the majority of orange varieties are derived from somatic mutations <sup>[4]</sup>, significant examples of mutants have played a fundamental role in the development of the varietal profile of orange trees, such as the *Cara Cara*, *Navelina* and *Navelate* (grown from *Washington Novel*), *Salustiana* (common orange), *Tarocco* (*Sanguinilli*) <sup>[5]</sup>, *Rohde*

*Red* (*Valencia Late*) <sup>[7]</sup> and the *Delta* and *Midnight* oranges <sup>[8]</sup>. Also, new varieties of orange trees were obtained by the somaclonal variation <sup>[9]</sup>. Also, the irradiation of the orange tree *Pineapple* made it possible to select clones with seedless fruits <sup>[10]</sup>. Moreover, the search for new hybrids of good quality orange and seedless fruit by spontaneous triploidization represents the primary axis of this study. Numerous research studies have been explored in terms of the application of triploidy for the genetic improvement of mandarins <sup>[10, 11, 12, 13, 14]</sup>. Among the stages of this genetic improvement, the crossbreeding of diploid parents followed by the rescue of immature embryos. Thus, the objective of this preliminary study is the selection of the best female parents of orange trees whose main criterion of varietal distinction would be the ability to be pollinated by presenting fruits with numerous seeds.

### 2. Materials and Methods

#### 2.1 Characteristics of the experimental site

The orange tree collection is planted at the El Menzeh estate (INRA Kenitra, altitude 25 m, latitude 34 ° 6'). The climate of this zone is of the Mediterranean type. The soil is sandy, siliceous at the surface (98%) and sandy, clay at depth, with a pH of 6, a retention capacity of 3 to 6% and a cation exchange capacity of 5 meq / 100g with no limescale. The 'microjet' irrigation system is compatible with the exploitation and availability of water. The quantities of water required to

irrigate the plot of land properly are defined according to the climatic zone. The water requirements of citrus fruits are estimated at around 1200 mm per year, distributed over the whole year. The average annual temperature was 15.45° C for the test, nitrogen fertilization (Amonitrate 33.5%) was divided into three annual intakes, distributed according to the following proportions: 50% before flowering, 25% after flowering and 25% after physiological fall. Potassium sulfate and triple super phosphate intakes were made in September and December respectively. Sanitary treatments have been

carried out against pests such as mealybugs, miners, mites, snails, etc. by pesticides such as vertimec, Confidor and Mesurool. Similarly, chemical weed control is obtained by glyphosate (Round up). The pruning was made between picking and flowering.

## 2.2 Vegetable material

The plant material under experimentation consists of 16 varieties of orange trees (Table 1);

**Table 1:** List of varieties of orange trees studied (Menzeh, INRA Kenitra)

| code | Orange tree      | Origin  |
|------|------------------|---|
| 1    | Valencia Late    | Originating in China and it is probably brought to in Europe by Portuguese and Spanish travellers [14, 12].                   |
| 2    | Parson Brown     | Was discovered in a thicket pertaining to Pearson Brown in Wester, Florida [15].  |
| 3    | Tarocco          | Mutation of sanguinelli [16, 17].   |
| 4    | Hamlin           | is a seedling of unknown parentage in an orchard close to Glenwood, in Florida [18, 13].                                      |
| 5    | Pineapple        | Is in a thicket close to Citra, in Florida. It was propagated in 1876 or 1877 under the name of Hickory' [15].                |
| 6    | Cadenera         | Is a seedling of unknown parentage of Spanish origin. It was founded in 1870 [14, 12, 18].                                    |
| 7    | Moro             | Mutation of Sanguinelli [19, 15].   |
| 8    | Grosse Sanguine  | Mutation of Doble Fina [16].  |
| 9    | Sanguinelli      | Mutation of Doble Fina variety, discovered in Spain in 1929 [18, 14].   |
| 10   | Salutiana        | Mutation of Common orange that was selected in Spain in 1950 <sup>th</sup> [20, 16].  |
| 11   | Vernia           | Is of Spanish variety from unknown origin [16].   |
| 12   | Washington Navel | Natural mutation that was selected of Bahia in Brazil at the end of the 18th century [20, 16].                                |
| 13   | Thomson          | Early mutation of Washington Navel introduced in California in 1891 [20, 16].   |
| 14   | Roberston        | Obtained as buds of Willits and Newcomb in California, 1996 [13].   |
| 15   | Doble Fina       | Of unknown Spanish origin, Double Fine has been, since many decades, the principal variety of blood orange in Spain [18, 14]. |
| 16   | Maltaise         | Of unknown origin [16].   |

## 2.3 Characteristics Evaluated

30 mature fruits were harvested, randomly, from different trees of the same variety. The collected samples are placed in plastic bags containing the code of each variety and returned to the laboratory to analyze the following parameters:

### 2.3.1 Pomological characteristics

#### a) Juice content in Percentage

The juice is extracted using an electric appliance (rotating rotor). The total juice corresponds to the decanted juice and the sifted juice.

The percentage of juice = (Weight of fruit juice / total weight of these fruits) x 100

#### b) Sugar content (E) or soluble dry extract (ESS)

The sugar content in the Juice is obtained by a direct reading on the portable optical refractometer and graduated by 0,32%.

#### c) Acidity of the Juice (A)

The acidity of the juice corresponds to the total amount of the mineral and organic free acids in the juice, It is citric acid mostly predominant and represents 85% to 95% of the total acids of citrus juices.

For the titration of the acidity of the juice, 10 ml of decanted juice was used and to which three drops of phenolphthalein were added. Noah's solution (0.1 M) is placed in a Mohr's burette and then was let to flow gently while waving the beaker until the start of the turn. This operation is essential, especially when the solution approaches neutrality. The end of

the titration is reached when the color of the juice becomes persistent and becomes pinkish.

#### d) Maturity coefficient (E/A)

The maturity index is the sugar ratio by the acidity of the juice. It is used to determine the maturity state of the fruit and is calculated based on the following formula:

$$E / A = \text{Sugar content (E) / Juice acidity (\%)} (A)$$

#### e) Average Weight of a fruit

This is the total weight of the sample divided by ten. It is appreciated using an electric scale.

## 2.4 Statistical analysis of data

The data obtained were analyzed using statistical software SAS 9.3 (STATISTIC ANALYSIS SYSTEM), as well as a principal component analysis (PCA) descriptive of all the variables. Finally, a dendrogram hierarchical representation was performed using the cluster test. These analyses are based on the treatment of the variables; the average fruit weight, the number of seeds per fruit, the sugar and juice content, the acidity and the maturity coefficient.

## 3 Results and discussion

### 3.1 Selection of Female relatives of orange Trees from the citrus collection

#### 3.1.1 Study of fruit Quality

There are significant differences (P <0.01) between orange varieties for all variables studied. Thus, the statistical results

and averages of all quality criteria are summarized in Table 2.

- Average fruit weight: It oscillated from 85g to 207g with an average value of 226g. Similarly, there is a significant difference between the 16 varieties of orange trees, so eight groups (a, ab, abc, abcd ... h) have been demonstrated. The variety *Tarocco* was characterized by the highest value, while the variety *Vernia* was distinguished by the small average weight value of the fruit.
- Number of seeds per fruit: The average value of NPF for orange varieties is 2.84. This number ranged from 0.35 to 11.80. Statistical analyses showed five groups (a, b, c, d, cd). The *Pineapple* and *Parson Brown* varieties showed fruit with numerous seeds of 11 and 6 respectively, while the varieties *Tarocco* and *Robertson* are characterized by aspermia.
- Titrateable acidity(A): The average value of the acidity of orange varieties is 1.51; it has fluctuated from 0.81 to 2.34. This variable depends on the date of analysis; Thus late varieties (*Valencia Late*, *Maltaise*, and *Vernia*) are very acid in November and December, while *Robertson* and *Thomson* are less acidic in the same period.
- Percentage of juice: it varied from 27% to 52% with an average value of 41%. Statistical analyses revealed five groups (a, ab, abc, abcd ... i). Thus the *Tarocco* variety is relatively the juiciest.
- Sugar content: The average value is 10.85, which varied from 9 to 12. Statistical analyses revealed 5 groups (a, ab, abc, abcd... h): the first one contains the highest value of the sugar content, namely *Hamlin*, whereas the last one contains the smallest value, namely *Valencia Late*, which only reaches maturity in March, while the juice analyses were carried out in Month of November.
- Maturity coefficient: The mean value of the maturity

coefficient is 7.83; And it oscillated from 3.82 to 13.10. Statistically, 13 groups were highlighted; precocious varieties are *Tarocco* and *Thomson*, while tardy varieties are *Valencia Late* and *Maltaise*, followed by *Pineapple*, *Sanguinilli* and *Vernia*. It is interesting to study the maturity period on three different dates for all varieties and to follow the evolution of the other quality criteria of the *Pineapple* and *Parson Brown* varieties because they represent highly seeded fruits in addition to the good quality.

### 3.1.2 Study of the evolution of fruit Quality

The study of fruit maturity evolution showed that the varieties differ in terms the coefficient of maturity (E / A) which depends on the sugar content and the acidity (Figure 1). According to the three dates of juice analysis, three groups were identified: the group 1 contains the precocious varieties (*Robertson*, *Thomson*, *Salustiana*, *Parson Brown*, *Hamlin*, *Grosse sanguine* and *Tarocco*); the second one consists of varieties such as (*W. Navel*, *Cadenera*, *Double fine*, *Vernia*, *Moro*, *Sanguinilli* and *Pineapple*) and the last one includes tardy varieties (*Valencia Late* and *Maltaise*).

Moreover, the quality variables studied, namely the average fruit weight, the number of seeds per fruit, the sugar and juice content, the acidity and the maturity coefficient, fluctuate according to the harvest dates, They are influenced by the varietal factor (Figure 2). The results show that the *Pineapple* variety represents a significant change in average fruit weight and the number of seeds per fruit over time. However, the *Parson Brown* variety was characterized by a very high juice and sugar content. Also, it is precocious variety in relation to the *Pineapple* variety. Regarding acidity, the two varieties *Pineapple* and *Parson Brown* experienced a significant decrease in acidity during the three harvest dates.

**Table 2:** Descriptive study of all quality variables during two years: 2015/2016 and 2016/2017.

| Varieties        | PMF (g)  | NPF    | JUS (%)  | A        | E        | E/A       |
|------------------|----------|--------|----------|----------|----------|-----------|
| Tarocco          | 207,5a   | 0.90cd | 52.02a   | 1.23efg  | 11.60ab  | 9.16bcd   |
| Robertson        | 162,5ab  | 0.35d  | 44.86ab  | 0.81g    | 10.50    | 13.10a    |
| Washington Navel | 162,5ab  | 2.05cd | 39.76abc | 1.39defg | 11.20ab  | 8.45bcdef |
| Thomson          | 155,0abc | 1.55cd | 26.81c   | 0.98fg   | 11.15abc | 12.14ab   |
| Maltaise         | 150,0abc | 2.90c  | 43.30ab  | 2.16ab   | 10.70abc | 4.90fg    |
| Salustiana       | 145,0abc | 2.05cd | 45.53ab  | 1.27efg  | 11.35ab  | 8.89bcdef |
| Moro             | 140,0abc | 1.95cd | 44.59ab  | 1.57cdef | 10.45abc | 6.61defg  |
| Valencia Late    | 137,5abc | 2.85c  | 38.85abc | 2.34a    | 9.10c    | 3.82g     |
| Cadenera         | 127,5bc  | 1.15cd | 43.33ab  | 1.46cdef | 11.64ab  | 7.90cdef  |
| Pineapple        | 120,0bc  | 11.80a | 38.88abc | 1.71bcde | 9.75bc   | 5.60defg  |
| Grosse Sanguine  | 115,0bc  | 2.85c  | 36.29bc  | 1.26efg  | 11.55ab  | 9.10bcde  |
| Parson Brown     | 115,0bc  | 5.90b  | 42.02abc | 1.49cdef | 11.20ab  | 7.51cdefg |
| Hamlin           | 115,0bc  | 1.85cd | 38.11abc | 1.10efg  | 11.85a   | 10.79abc  |
| Double Fine      | 112,5bc  | 2.45cd | 41.28abc | 1.56cdef | 10.45abc | 6.70defg  |
| Sanguinilli      | 102,5bc  | 3.05c  | 44.40ab  | 1.98abcd | 10.90abc | 5.54defg  |
| Vernia           | 85,0c    | 1.85cd | 39.42abc | 2.00abc  | 10.25abc | 5.11efg   |

PMF (g): average weight fruit in g. NPF: number of seeds per fruit. E / A: maturity coefficient. E: The sugar content. JUS (%): juice content. A: acidity. Values bearing the same letters are significantly indifferent with  $p > 5\%$ .

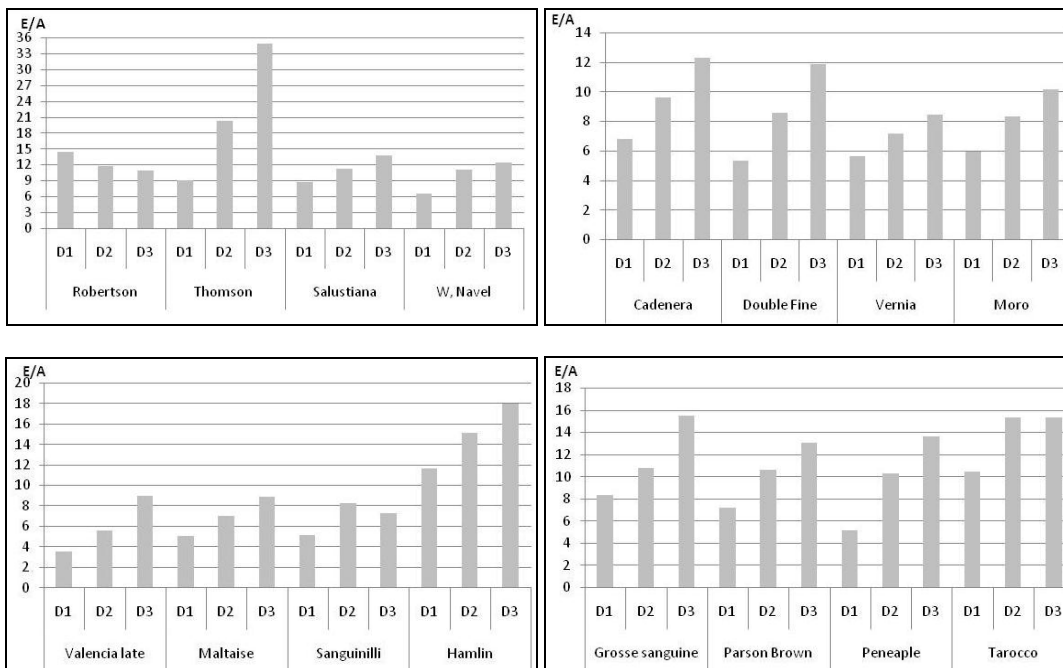


Fig 1: Evolution of fruit maturity of orange varieties according to the three dates of juice analysis.

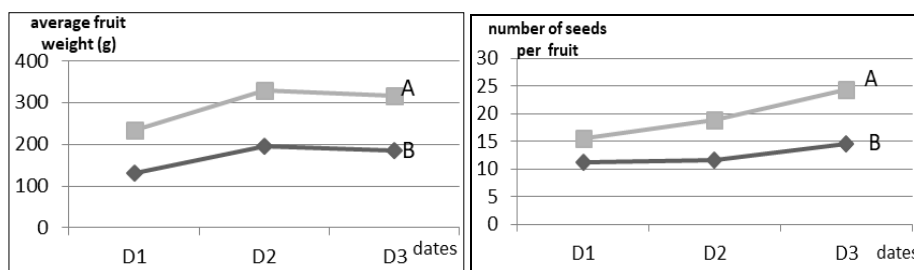


Fig 2: Variation in average fruit weight and number of seeds per fruit of both varieties (Pineapple and Parson Brown) in terms of time.

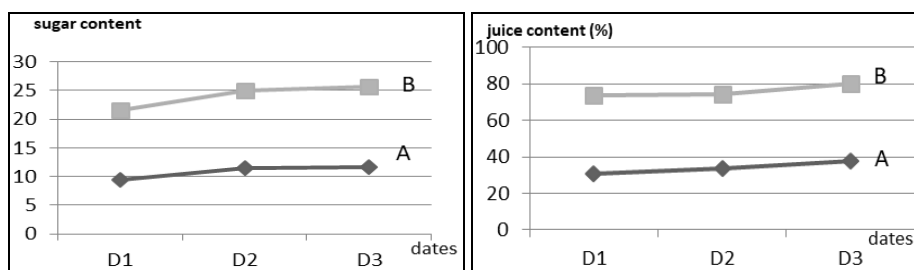
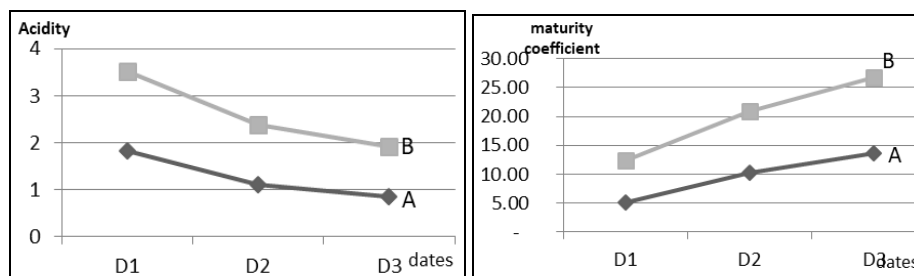


Fig 3: Variation in sugar and juice content of both varieties (Pineapple and Parson Brown) in terms of time.



D1. 24/11/2015. D2. 19/01/2016. D3. 12/02/2016. A. Pineapple. B. Parson Brown.

Fig 4: Variation in acidity and maturity coefficient of the two varieties (Pineapple and Parson Brown) in terms of time.

### 3.1.3 Application of the principal components analysis (PCA) on all orange trees

Principal Components Analysis (PCA) (Figure 6) shows the correlation between organoleptic variables: mean fruit weight, number of seeds per fruit, sugar and juice content, acidity, maturity coefficient and the sixteen varieties of orange trees on the other hand. In fact, the F1 and F2 axes reach 70.75% of

the total variability which is reliable to carry out the APC. Although the projection of the variables along the F1 axis showed that the average fruit weight, sugar content and maturity coefficient were negatively correlated with the number of seeds per fruit and acidity, The F1 axis, showed that the average fruit weight is positively correlated with the juice content.

**Table 3:** Descriptive study of all variables studied

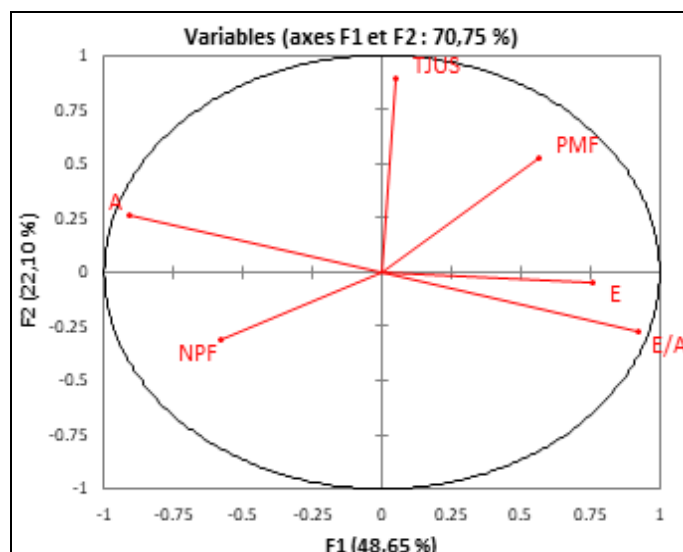
| Variable | Observations | Minimum | Maximum  | average  | Standard deviation |
|----------|--------------|---------|----------|----------|--------------------|
| PMF      | 16           | 85,0000 | 207,5000 | 134,5313 | 29,5130            |
| NPF      | 16           | 0,3500  | 11,8000  | 2,8438   | 2,6874             |
| TJUS     | 16           | 26,8100 | 52,0200  | 41,2156  | 5,4003             |
| A        | 16           | 0,8100  | 2,3400   | 1,5194   | 0,4299             |
| E        | 16           | 9,1000  | 11,8500  | 10,8525  | 0,7466             |
| E/A      | 16           | 3,8200  | 13,1000  | 7,8325   | 2,6477             |

**Table 4:** Correlation matrix

| Variables | PMF    | NPF    | TJUS   | A      | E      | E/A    |
|-----------|--------|--------|--------|--------|--------|--------|
| PMF       | 1      | 0,3193 | 0,3302 | 0,3866 | 0,1928 | 0,4144 |
| NPF       | 0,3193 | 1      | 0,1525 | 0,2920 | 0,3873 | 0,4035 |
| TJUS      | 0,3302 | 0,1525 | 1      | 0,0956 | 0,0961 | 0,1791 |
| A         | 0,3866 | 0,2920 | 0,0956 | 1      | 0,6236 | 0,9618 |
| E         | 0,1928 | 0,3873 | 0,0961 | 0,6236 | 1      | 0,5852 |
| E/A       | 0,4144 | 0,4035 | 0,1791 | 0,9618 | 0,5852 | 1      |

**Table 5:** Clean values

|                 | F1      | F2      |
|-----------------|---------|---------|
| Clean values    | 2,9190  | 1,3258  |
| variability (%) | 48,6503 | 22,0964 |
| % accumulated   | 48,6503 | 70,7467 |



PMF (g). average weight per fruit in g. NPF. number of seeds per fruit. E / A. maturity coefficient. E. The sugar content. TJUS (%). juice content. A. acidity

**Fig 5:** Projection of the variables on the factorial design F1 x F2 (70.75%).

According to the correlation circle, we can deduce a strong positive correlation of the variables such as the sugar content, the maturity coefficient on the F1 axis by bringing a variability information of 48.65%, while the acidity variables

and the number of seeds per fruit are negatively correlated on the same axis. In addition, the mean weight per fruit of the variables and the juice content were positively correlated on the F2 axis with variability information of 22.10%.

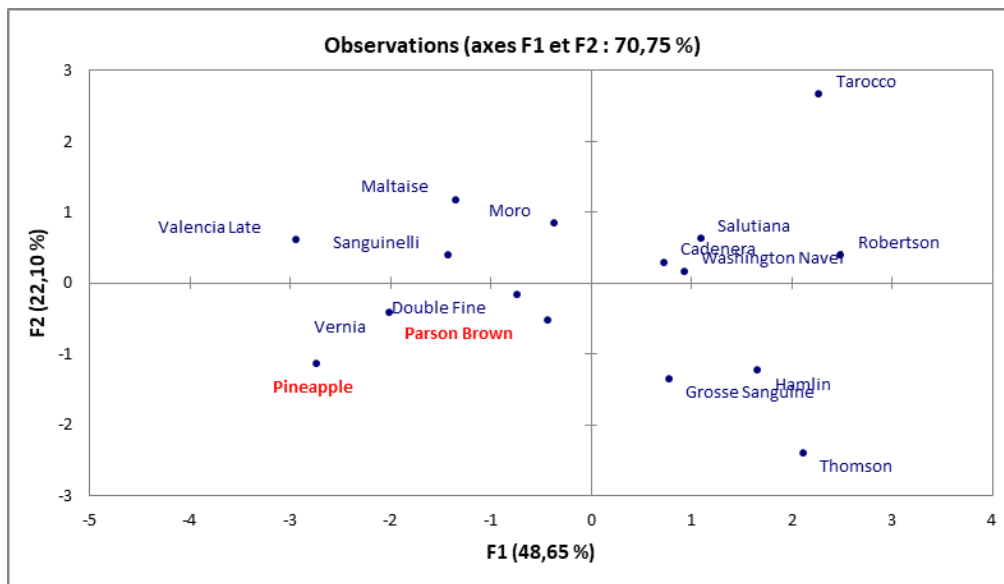


Fig 6: Projection of individuals on the factorial design F1 x F2 (70.75).

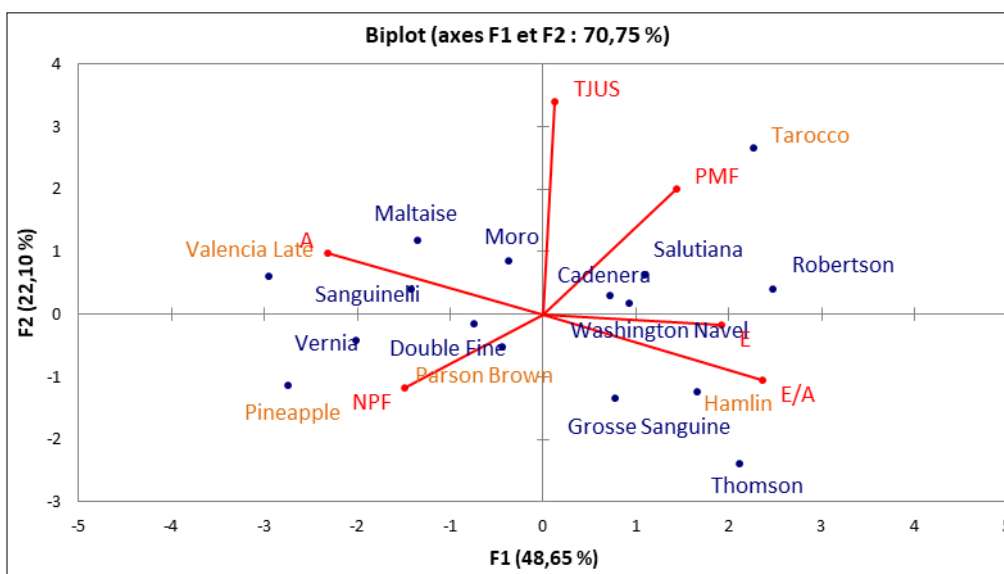


Fig 7: Projection of variables and individuals on the factorial design F1 x F2 (70.75).

Figure 7 shows the mapping of individuals (species studied) that come together and come closer together according to their resemblance, explained by Euclidean distance.

Thus, the distribution of these species is conditioned by the total inertia of the variables on the factorial design F1 x F2 and is subdivided between the F1 (48.65%) and F2 (22.10%) axes. According to axis F1, the *Pineapple* and *Parson Brown* orange trees were characterized by a very large number of seeds per fruit. Similarly, the varieties *Valencia Late* and *Maltaise* are very acid.

In addition, the varieties *Hamlin*, *Robertson* and *Thomson* have a high level of sugar content and, maturity.

According to axis F2, *Tarocco* orange was characterized by a medium fruit weight and very important juice content.

### 3.1.4 Hierarchical ascending classification (HCA)

The overall analysis of all the variables represented in mean fruit weight, number of seeds per fruit, sugar and juice content, acidity and maturity coefficient, could define a dendrogram (Figure 9) according to three distinctive groups:

1st group: *Pineapple*, *Gosse sanguine*, *Hamlin*, *Parson Brown*, *Double Fine*, *Sanguinelli* and *Vernia*.

2nd group: *Tarocco*.

3rd group: *Thomson*, *Robertson*, *Washington Navel*, *Maltaise*, *Salutiana*, *Moro*, *Valencia Late* and *Cadenera*.

Besides, the orange varieties *Pineapple* and *Parson Brown* are in the same group. This reveals that they have similar characters.

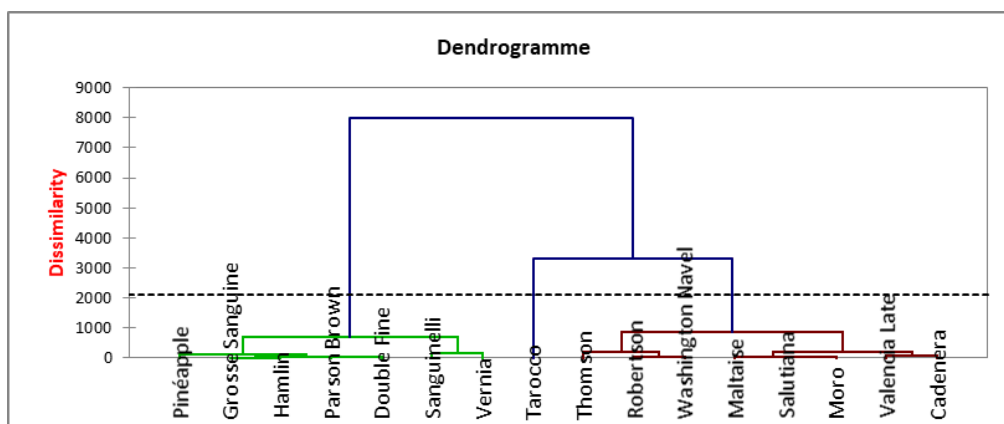


Fig 8: Cluster dendrogram of some orange varieties.

The quality of the fruit varies according to the variety; This is similar to several research studies [22, 23]. The *Tarocco* variety has been characterized by a relatively high weight, as found by [14, 24, 25]. Thus, the average weight of the fruit is related to weather conditions, rootstock, plant growth regulators, seed number and fruit juice content [26, 27].

In the case of juice yield, the juice content is a quality index for citrus fruits. Indeed, the juiciest fruits are the most in demand and the most appreciated by consumers. Except for the *Thomson* variety, all orange varieties yielded fruit with a juice percentage of more than 35% which corresponds to the minimum juice content for citrus fruit exports [28]. The juiciest variety is *Tarocco*, and our result is consistent with previous studies [20, 29]. This variability of juice is related to the frequency of irrigation, date of harvest, age of the tree and the position of the fruit [30].

Brix percentage variability is more pronounced among orange varieties. Indeed, the values range from 9.10 to 11.85. In this context, the highest levels of sugars were recorded in *Hamlin* and *Tarocco*, while *Valencia Late*, which came to maturity in March, showed a poor juice content since the juice analyses were carried out in November. The sugar content (ESS) fluctuates according to variety, maturity and weather conditions. For orange trees, a minimum content of 9.5% is required [28].

The total acidity of the juices studied showed that the juice of the *Valencia Late* variety is the most acid, followed by that of *Maltaise*, while the juice of *Robertson* is the least acid. These values correspond to the standards since the minimum acid content of orange trees is 1 [28]. Acidity values depend largely on climate, variety and degree of maturity [32]. Organic acid contents generally fall near fruit maturity [33], where acidity plays a very important role in the determination of the E / A ratio.

The evaluation of the maturity index makes it possible to determine the date of harvest of the fruit. Thus, the calculation of the maturity index revealed an ratio  $E / A > 7$  (minimum value from which to harvest oranges) [28]. The variability of the juice content in total sugars and titratable acidity gave distinct indices of maturity between 3.82 and 13.10. This heterogeneity may be understandable when changes occur in texture, bark color, the juice composition and the organoleptic

level [33, 34]. And also according to [14], citrus fruits are considered mature when their external coloring, juice, sugar content, acidity ratio and other internal constituents have reached a minimum level of visual acceptance.

### 3.1.5 Selection of best Female parents

Among the bibliographic constraints in orange trees, gametes sterility makes it difficult to use conventional genetic improvement methods. Thus, the criterion of the number of seeds per fruit makes it possible to select the varieties according to their ability to be pollinated, and we found only the orange varieties *Parson Brown* and *Pineapple* which are characterized by a relatively large number of seeds that other orange varieties do. They are moderately juicy, sweet, less acidic and more precocious, these results are similar to those found by [35, 36, 1]. The variability of seed numbers is generally related to the pollinator variety [36]. Thus, better pollination results in a lot of seeds in the fruit [29, 35].

In addition, these two varieties of *Pineapple* and *Parson Brown* orange are self-incompatible [37, 38, 39], as they tend to be crossed with other varieties to cause seed formation in fruits which will be used for triploidisation. In addition, these two varieties of orange trees are classified among the most exploited varieties in juice industries [20, 40].



Fig 9: Variety of orange Pineapple



Fig 10: Variety of orange Parson Brown

#### 4. Conclusion

From this work, we can conclude that the orange varieties (*Parson Brown*, *Pineapple*) have been shown to be promising to serve the crossbreeding program between diploid parents in order to spontaneously create new hybrid triploids of orange trees. The results of this research showed that the *Tarocco* variety is juicy and the varieties *Hamlin*, *Thomson* and *Robertson* are precocious on one side and the varieties *Valencia Late* and *Maltaise* are tardy on the other hand.

#### 5. Références

- Ajanid I. Association des Producteurs d'Agrumes au Maroc: Les Objectifs et les Perspectives. Agrimaroc, 2016.
- Le F. Bellec Reconception et evaluation des systèmes de culture. Antilles, Guyane: Université d'Antilles, Guyane, 2011.
- Fardaoussi M. Morocco citrus annual report. Global Agricultural Information Network, 2015; 1-19.
- Stover E, Driggers RCJ, Hearn J, Bai Baldwin E, McCollum TG, DG Hall. Breeding sweet oranges at the USDA US Horticultural Research Laboratory. ISHS Acta Horticulturae. Brisbane, Australia :ISHS Acta Horticulturae, 2014; 1-183.
- Jacquemond C, Curk F, Heuzet M. Les clémentiniers et autres petits agrumes. Versailles: Quae, 2013.
- Ollitrault P, Rocca D, Serra L'amélioration des agrumes: II. Créations variétales et biotechnologies. Agritrop, 1992; 47:124-134.
- Rouse RE. Citrus fruit quality and yield of six Valencia Clones on 16 rootstocks in the immokalee foundation grove. Proceedings of the Florida State Horticultural Society, 2000; 112-114.
- Tribulato E, Rosa G, Nicolosi E. New accessions of Valencia late orange. Rivista di frutticoltura e di Orto, floricoltura, 2001; 632:9-32.
- Grosser JW, Gmitter FG, Chandler JL. Somaclonal variation in sweet orange-Practical application for variety improvement and possible causes. In Ak, Iqar ed. Citrus genetics, breeding and biotechnology. Wallingford, England: CAB International North America, 1996; 750-985.
- McCullum TG, Bowman KD. Fruit and juice quality of seedless pineapple oranges on four rootstocks. Proc. Fla. State Hort. Soc, 2005; 11:1-3.
- Froelicher Y. Amélioration génétique des agrumes: Gestion de la diversité et de la ploïdie. Agritrop, 2010; 1:1-100.
- Handaji N, Benyahia H, Arsalane NA, Ben Azouz, F Gaboun. Evaluation pomologique et organoleptique de 34 variants d'orangers *Citrus sinensis* L. Osbeck issus de semis apomictique en essai dans la région du Gharb. Moroccan Journal of Agricultural Research al, awamia, 2007; 1:45-70.
- Aleza P, Juárez J, Cuenca J, Ollitrault PNL. avarro Extensive citrus triploid hybrid production by  $2x \times 4x$  sexual hybridizations and parent, effect on the length of the juvenile phase. 2012 ; 31:1723-1735.
- Morton JF. Fruits of warm climates, 1987; 1:134-142.
- Saltini A. I cento volti di Trinacria. Viaggi of otograficonella Sicilia agricola, Ismea Spaziorurale, Rome, 2004, 11.
- Hodgson RW Horticultural variétés of citrus. The Citrus Industry California: University of California, 1967; 15-55.
- Handaji N, Arsalane N, Ben A, Azouz I, Srairi A, Sagide F Gaboun, Benyahia H. A program of the diversification the mandarins and oranges varieties in Morocco. Journal of Applied Bioscience, 2008; 57:4197-4186.
- Agrumes de sicile.suonvicini AG, 2011; 4:1-5.
- Jacquemond C, Agostini D, CUR K. Des agrumes pour l'Algérie. Algeria : Bureau d'ingénierie en horticulture et agro, industrie, 2009, 1-59.
- Kisenger M. Citrus budwood annual report. Bureau of Citrus Budwood Registration; 2015:1-31.
- Harley Manner I, Richard S, Buker ES, Virginia W. Deborah Craig R. Crop Profile for Citrus Minor Lime, Pummelo, and Kumquat in Florida. Species Profiles for Pacific Island Agroforestry, 2001; 1-36.
- Bondoux PW. Maladies de conservation des fruits à pépins. Pommes et poires, 1992.
- Allain E. La pomme golden, France Agrimer. ISSN.2492,6299, 2015; 1-8.
- Barry GH, Davies FS, Castle WS. Soluble solids in Valencia Sweet orange as related to Rootstock selection and fruit size. J Am. Soc. Hort. Sci., 2004; 598-598.
- Saifur R, Abdul Iqtidar A, Abdul AG. Qualitative aspects of various cultivars of sweet oranges *Citrus sinensis*. Food and Agriculture Organization of the United Nations, 1983; 24-27.
- Wutscher HK, Bowman KD. Performance of Valencia Orange on 21 Rootstocks in Central Florida. Hortscience, 1999; 34:622-624.
- Jakson JE, Hamer PJC. The causes of year to year variation in the average yield of Cox's Orange Pippin apple in England doi:10.1080/00221589.1980.11514917, 1980.
- NORME CEE, ONU FFV 14. Commercialisation et le contrôle de la qualité commerciale des agrumes. 2016; 1-13.

29. Liu F, Liang Y, Wang Y. A simple method of spot picking for higher quality Ponkan mandarins by selecting locations of the tree. *Journal of the Taiwan Society for Horticultural Science*, 2012; 58:11-18.
30. H Hui Y. *Handbook of fruits and fruit processing*, 2007.
31. Osborne T *Tarocco blood orange*, 2016.
32. Fellers Citrus PJ. Sensory quality as related to rootstock, cultivar, maturity and season. *Spinger Link*. 1985; 83-128.
33. Cabezas G. Rodríguez E. Horticultural techniques for improving orange fruit *Citrus sinensis*L. size and quality. *Agronomía Colombiana*, 2010; 28:55-62.
34. Davies FS, Albrigo LG. *Citrus corp production In horticulture CAB*, 1994; 21:201-206.
35. Handaji N, Benyahia H, Arsalane N, Ben Azouz A, Gaboun F. Evaluation pomologique et organoleptique de 34 variants d'orangers *Citrus sinensis* L. Osbeck issus de semis apomictique en essai dans la région du Gharb. *Moroccan Journal of Agricultural Research al, awamia*; 2013; 11-26.
36. Beridze ND, Masuradze NI. Some factors affecting fruit and seed set in oranges. *SubtropicheskieKul'tury*, 1991; 2:138-14.
37. YK Chan G, Coppens G. Sanewski Breeding and variety improvement. In P.E. Bartholomew and E. Robert eds *The pineapple: Botany, Production and Uses*. Wallingford: CABI, 2003; 4:33-55.
38. Jackson J. Imidacloprid & Thiamethoxam: Need for Label with Higher Rates of AI Position Statement. *research coordinating council florida citrus industry*, 2010; 1:1-4.
39. Reuther W, Herbert JW. *The citrus industry: anatomy, physiology, genetics, and reproduction, science. gov*, 1967, 1.
40. Bailey CC. *CITRUS sinensis Pineapple*, 1992.