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Production Systems

# Fruit maturity evolution of Clementine Mandarin variety (strain 88) grafted on different citrus rootstocks

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***Abstract.*** *The research was carried out at Ciano Research Station of Lattakia Research Center - General Commission for Scientific Agricultural Research in Damascus in 2019. The fruit maturity evolution of Clementine Mandarin variety (Strain 88) budded on seven citrus rootstocks (Sour Orange, Citrumelo 4475, Citrumelo 1452, Troyer Citrange, Carrizo Citrange, Macrophylla and Cleopatra Mandarin) and planted in 1989 was studied for a period of 84 days, starting from 16th September 2019 to the start of reaping the fruits on 9th December 2019. There were insignificant differences in the average weight increase of the fruit among the studied treatments. Fruit peel thickness significantly increased by (50.15%) in the trees grafted on Macrophylla compared to those grafted on Cleopatra Mandarin, Troyer Citrange and Citrumelo 1452 whose fruit peel thickness increased by (19.21, 9.58 and 2.61%, respectively). The highest increase in total soluble solids (%) was in the trees grafted on Troyer Citrange by (38.10%), while total acids (%) significantly decreased by (18.33%) in the trees grafted on Citrumelo 1452.*

**Keywords**: Clementine, rootstocks, maturity, fruit

## Introduction

Citrus cultivation in Syria is an important economic activity. In Syria, there were 14,370,900 citrus trees covering 43,254 hectares in 2020. Of these, 13,796,500 trees reached the fruiting stage, producing 833,654 tons of fruits. Mandarin trees accounted for 2,861,700 of the total, spanning 8,664 hectares and yielding 183,055 tons of fruits according to the Statistical group of the ministry (2020) of agriculture and agrarian reform in 2020. The Clementine group is one of the distinctive Mandarin varieties that appeared in Algeria in the late nineties of the nineteenth century. There are different selections of Satsumas and Clementines such as the hybrids of tangelo (crossed with pummelo or grapefruit) and tangor (crossed with sweet orange) (Ogunrinde et al., 2007).

Many citrus varieties suffer from diseases and problems, the most important of which is the viral rapid deterioration disease (Tristeza) (Ballester - Olmos et al., 1988) and fungal gum disease (Bitters and Batchelor, 1952), and there are many other problems such as frost, lime, salinity, waterlogging, drought, etc., so we must choose the appropriate rootstock which is adapted to the environment, resistant to insects and diseases, positively affects yield and quality, compatible with the scion and increases earliness and age of trees grafted on (Lacey and Foord, 2006).

Cimen (2019) mentioned the important role of rootstocks in the rapid evolution of citrus farming around the world. Using rootstocks is essential for achieving adequate production given various challenges in citrus cultivation such as climate, unsuitable soil, diseases and other limiting factors. It was found that the difference of studied rootstocks used in grafting W. Murcott Mandarin variety did not affect the fruit weight or the fruit content of total soluble solids (TSS), but it did affect the fruit content of juice, total acids (TA) and maturity coefficient. Ahmed et al. (1980) showed that Clementine trees grafted on Sour Orange gave small size fruits but rich in total soluble solids, total acids and ascorbic acid, while the fruits of trees grafted on Rough Lemon were large in size but their content of total soluble solids, total acids and ascorbic acid was low.

Fallahi and Rodney (1992) indicated that fruit content of TSS was the highest in Fairchild Mandarin trees grafted on Carizzo Citrange, while fruit contents of TSS and TA were the lowest in the trees grafted on Volkamer Lemon and Rough Lemon. Nevertheless, Volkamer Lemon, Carrizo Citrange, Taiwanica, and Rough Lemon were suitable for grafting Fairchild Mandarin in the arid regions to obtain good growth and production in quantity and quality, while it was possible to graft Fairchild Mandarin on Macrophylla if planted for a shorter exploitation period, which resulted in a decrease in growth and production with the aging of the trees.

Stenzel et al. (2003) observed the absence of significant differences in the fruit weight among the treatments when studying the performance of (Ponkan) Mandarin grafted on 7 rootstocks. Also, Mourão Filho et al. (2007) study of the growth and production of the two mandarin varieties (Fallglo and Sunburst) grafted on 4 rootstocks revealed that the highest fruit contents of TSS and TA were in the trees grafted on Swingle Citrumelo and Cleopatra Mandarin, and the lowest value of the maturity coefficient was in the trees grafted on Swingle Citrumelo for both varieties. Results of a similar study on the growth and production of Fearmont Mandarin variety grafted on 4 rootstocks showed that fruit contents of TSS and TA were the highest in the trees grafted on Swingle Citrumelo and Cleopatra Mandarin too (Espinoza-Núñez et al., 2007).

Morales et al. (2020) noticed that fruit quality of Clemenules Mandarin variety was affected by the variation of the rootstock used for grafting, and this effect depended on the harvest time. Cleopatra Mandarin decreased the value of the maturity coefficient in the early stage of harvest, while it increased the value of the maturity coefficient in the last stage of harvest. Carrizo Citrange gave the highest fruit content of sucrose, while Macrophylla gave the lowest fruit content of sucrose.

Studying the yield and fruit quality of two mandarin varieties (Robinson and Nova) grown in the Mediterranean climate for 6 years, Demirkeser et al. (2009) observed that fruit weight and its seeds number were affected by the rootstock variation in Nova Mandarin, and the largest fruit weight was in the trees grafted on Troyer Citrange. Fruit weight and its number of seeds in Robinson Mandarin were not affected. Anyway, fruit color and skin structure were affected. Rootstocks effect on peel thickness, fruit diameter, fruit content of juice, TSS, TA and maturity coefficient were similar in both varieties. Carrizo and Troyer Citrange can be adopted as alternatives rootstocks to Sour Orange in grafting Mandarin trees.

Garcia-Sanchez et al. (2006) found that salinity decreased the fruit content of juice in Clemenules Mandarin, while it increased its content of TSS in the trees grafted on Carrizo Citrange. Yield was decreased under salinity conditions due to the decrease in the number of fruits on the tree but not their size.

The importance of this research is to understand the dynamics of Clementine tree fruit maturity and how different rootstocks influence it under the conditions of the Syrian coast.

The research aims to study fruit maturity evolution of Clementine Mandarin (strain 88) grafted on 7 rootstocks used globally in grafting citrus varieties and determine the changes of fruit maturity till harvest under Syrian coast conditions.

## Material and methods

*Area and period of the study*

The research was carried out during 2019 at the citrus research station of Ciano - Jableh - the agricultural scientific research center in Lattakia.

*Plant material*

**Scion**: The fruit maturity evolution of Clementine Mandarin (Strain 88) was studied. The fruit is medium-sized with a juicy pulp, an orange peel, few seeds, and it matures early.

The trees, planted in 1989, had a spacing of 6 x 6 m.

**Rootstocks**: The effect of 7 citrus rootstocks on fruit maturity evolution of Clementine has been studied. These rootstocks are as follows:

1. Sour orange *Citrus aurantium* (L).
2. Citrumelo 4475 (*C. paradisi* Macf. × *Poncirus trifoliata* (L.) Raf.).
3. Citrumelo 1452 (*C. paradisi* Macf. × *Poncirus trifoliata* (L.) Raf.).
4. Troyer Citrange (*C. sinensis*. (L). × *P. Trifoliata*. (L). Raf.).
5. Carrizo Citrange (*C. sinensis*. (L). × *P. Trifoliata*. (L). Raf.).
6. Macrophylla *C. macrophylla* Wester, Alemaow.
7. Cleopatra mandarin (*C. reticulata* Blanco).

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*Measurements*

Some physical and chemical properties of 10 fruits taken randomly from all sides of each tree were studied on two dates: the first date is 16-9-2019 (124 days after the fruits began to form, which was on 15-5-2019) and the second date was on 9-12-2019 at the beginning of harvest (84 days after the first date and 208 days from the formation of the fruits).

Fruit maturity evolution was determined by comparing measurements from the two dates and expressing the difference as a percentage (%). The studied characteristics included:

**1- Physical properties of fruits:** Average fruit fresh weight (g), peel thickness (mm), pulp thickness (cm) by a manual caliper, percentage of juice in relation to fruit weight (%).

**2- Chemical properties of fruits:** Proportion of total soluble solids in juice (TSS) was measured by using the hand refractometer (%), percentage of total acids in fruit juice (TA) was determined (%) by titration with NaOH (Palikiva, 1988), and maturity coefficient (TSS:TA ratio).

*Statistical design and data analysis*

A randomized complete block design was adopted with 7 treatments and 4 replications, each replicated plot consisting of 1 Clementine Mandarin (Strain 88) tree grafted on one of the studied rootstocks. Data were statistically analyzed using a one-way ANOVA in a general linear model with 'SPSS for Windows'. Mean differences were assessed using the Duncan test (P = 0.05). The results were presented as mean ± standard deviation of mean (n=4).

## Results and discussion

Evolution of fruit physical properties of Clementine Mandarin (strain 88) grafted on different citrus rootstocks.

*Fruit fresh weight*

The results in Table 1 show a significant superiority of the grafted trees on Citrumelo 1452 in the average fruit fresh weight (53.70 g) to the trees grafted on the rest of the rootstocks after 124 days of fruit formation, while the differences were insignificant among the studied treatments at harvest after 208 days of fruit formation.

**Table 1.** Fruit fresh weight evolution of Clementine Mandarin (strain 88) grafted on different citrus rootstocks

| Rootstock | Fruit weight after 124 days of fruit formation (g) | Fruit weight after 208 days of fruit formation (g) | Fruit weight evolution (%) |
|---|---|---|---|
| **Sour Orange** | 29.60±6.43$^{b}$ | 65.65±5.49$^{a}$ | 132.56 ±68.12$^{ab}$ |
| **Citrumelo 4475** | 28.50±4.23$^{b}$ | 74.20±5.39$^{a}$ | 163.99±36.36$^{a}$ |
| **Citrumelo 1452** | 53.70±19.56$^{a}$ | 66.80±4.04$^{a}$ | 37.58±48.94$^{c}$ |
| **Troyer Citrange** | 38.60±5.39$^{b}$ | 66.30±11.36$^{a}$ | 73.08±30.94$^{bc}$ |
| **Carizzo Citrange** | 37.60±6.80$^{b}$ | 71.60±13.34$^{a}$ | 90.79±14.27$^{bc}$ |
| **Macrophylla** | 25.20±3.38$^{b}$ | 69.05±9.39$^{a}$ | 175.62±34.10$^{a}$ |
| **Cleopatra Mandarin** | 28.65±2.78$^{b}$ | 73.40±12.32$^{a}$ | 158.92±53.19$^{a}$ |

Figures that share the same letter on the column have no significant differences, according to the Duncan test (P < 0.05).

Fruit fresh weight evolution showed a significant increase in the trees grafted on Macrophylla, Citrumelo 4475 and Cleopatra Mandarin by (175.62, 163.99 and 158.92%, respectively) compared to the trees grafted on the rootstock Carrizo Citrange, Troyer Citrange and Citrumelo 1452 (90.79, 73.08 and 37.58%, respectively), and a significant increase in the trees grafted on Sour orange (132.56%) compared to the increase in the trees grafted on Citrumelo 1452.

These results are consistent with the results of Stenzel et al. (2003) and Cimen (2019) which showed that rootstock variation did not affect fruit fresh weight at harvest stage, while the results are not compatible with the results of Ahmed et al. (1980) which showed that Clementine trees grafted on Sour Orange gave fruits small in size. The results indicated a rapid increase in fruit weight in the last stages of maturity in the trees grafted on Macrophylla, Citrumelo 4475 and Cleopatra Mandarin compared to those grafted on Carrizo, Troyer Citrange and Citrumelo 1452, consequently all the rootstocks gave fruits of the same weight at harvest time. It can be said that Citrumelo 1452 affects fruit weight in the early stages of fruit formation, while the rest of rootstocks such as Macrophylla, Citrumelo 4475 and Cleopatra Mandarin contribute to an increase in fruit weight in the last stages of fruit ripening.

*Fruit peel thickness*

The results of studying fruit peel thickness showed insignificant differences among the treatments after 124 days of fruit formation. The trees grafted on Macrophylla were significantly superior in fruit peel thickness (2.84 mm) to the trees grafted on Cleopatra Mandarin and Troyer Citrange (2.21 and 1.96 mm, respectively) after 208 days of fruit formation as shown in Table 2.



**Table 2.** Fruit peel thickness evolution of Clementine Mandarin (strain 88) grafted on different citrus rootstocks

| Rootstock | Fruit peel thickness after 124 days of fruit formation (g) | Fruit peel thickness after 208 days of fruit formation (g) | Fruit peel thickness evolution (%) |
|---|---|---|---|
| **Sour Orange** | 1.94 ±0.14$^{a}$ | 2.37±0.17$^{ab}$ | 22.50±9.83$^{ab}$ |
| **Citrumelo 4475** | 1.84±0.10$^{a}$ | 2.42±0.20$^{ab}$ | 31.46±6.23$^{ab}$ |
| **Citrumelo 1452** | 2.21±0.31$^{a}$ | 2.26±0.54$^{ab}$ | 2.61±20.90$^{b}$ |
| **Troyer Citrange** | 1.83±0.32$^{a}$ | 1.96±0.08$^{b}$ | 9.58±21.10$^{b}$ |
| **Carizzo Citrange** | 1.92±0.35$^{a}$ | 2.35±0.48$^{ab}$ | 23.52±17.35$^{ab}$ |
| **Macrophylla** | 1.92±0.21$^{a}$ | 2.84±0.31$^{a}$ | 50.15±26.64$^{a}$ |
| **Cleopatra Mandarin** | 1.85±0.26$^{a}$ | 2.21±0.40$^{b}$ | 19.21±12.87$^{b}$ |

Figures that share the same letter on the column have no significant differences, according to the Duncan test (P < 0.05).

Studying fruit peel thickness evolution indicated a significant increase in the trees grafted on the Macrophylla by 50.15% compared to the trees grafted on Cleopatra Mandarin, Troyer Citrange and Citrumelo 1452 in which fruit peel thickness increased by 19.21, 9.58 and 2.61%, respectively.

These results do not confirm the results of Demirkeser et al. (2009) regarding the absence of a significant effect of the rootstock on fruit peel thickness at harvest time. Nevertheless, the increase in fruit peel thickness is a positive characteristic because of its importance in increasing fruits tolerance to marketing, shipping and storage. Therefore, the increase in fruit peel thickness in trees grafted on Macrophylla is a characteristic of this rootstock comparable to Cleopatra Mandarin and Troyer Citrange. So, the fruit peel thickness evolution varies according to the rootstock and the stage of maturity, for example, the effect of Citrumelo 1452 on fruit peel thickness appears in the early stages of fruit ripening compared to Macrophylla the effect of which appears in the later stages of fruit ripening.

*Fruit pulp thickness*

The results shown in Table 3 reveal that the trees grafted on Citrumelo 1452 are significantly superior in fruit pulp thickness (2.16 cm) to the trees grafted on Troyer Citrange, Sour Orange, Citrumelo 4475 and Macrophylla (1.93, 1.87, 1.79 and 1.68 cm, respectively) after 124 days of fruit formation, and the trees grafted on Cleopatra Mandarin (1.96 cm) and Troyer Citrange significantly outperformed the trees grafted on Macrophylla as well, while the differences were insignificant among the treatments at the beginning of the harvest after 208 days of fruit formation.

**Table 3.** Fruit pulp thickness evolution of Clementine Mandarin (strain 88) grafted on different citrus rootstocks

| Rootstock | Fruit pulp thickness after 124 days of fruit formation (g) | Fruit pulp thickness after 208 days of fruit formation (g) | Fruit pulp thickness evolution (%) |
|---|---|---|---|
| **Sour Orange** | 1.87±0.07$^{bc}$ | 2.51±0.05$^{a}$ | 34.08±4.11$^{abc}$ |
| **Citrumelo 4475** | 1.79±0.07$^{bc}$ | 2.47±0.12$^{a}$ | 38.23±5.80$^{ab}$ |
| **Citrumelo 1452** | 2.16±0.19$^{a}$ | 2.65±0.38$^{a}$ | 22.50±11.75$^{c}$ |
| **Troyer Citrange** | 1.93±0.15$^{b}$ | 2.38±0.14$^{a}$ | 23.72±11.51$^{bc}$ |
| **Carizzo Citrange** | 1.97±0.18$^{ab}$ | 2.47±0.16$^{a}$ | 26.37±14.19$^{bc}$ |
| **Macrophylla** | 1.68±0.14$^{c}$ | 2.43±0.07$^{a}$ | 45.19±10.23$^{a}$ |
| **Cleopatra Mandarin** | 1.96±0.13$^{ab}$ | 2.48±0.10$^{a}$ | 26.58±6.07$^{bc}$ |

Figures that share the same letter on the column have no significant differences, according to the Duncan test (P < 0.05).

A significant increase was indicated in fruit pulp thickness in the trees grafted on Macrophylla (45.19%) compared to the increase in fruit pulp thickness in the trees grafted on Cleopatra Mandarin, Carrizo Citrange, Troyer Citrange and Citrumelo 1452 (26.58, 26.37, 23.72 and 22.50, respectively), and there was a significant increase in pulp thickness in the trees grafted on Citrumelo 4475 (38.23%) compared to Citrumelo 1452.

These results are consistent with the results of Demirkeser et al. (2009) as the differences were insignificant in fruit pulp thickness in the two mandarin varieties (Robinson and Nova) grafted on different rootstocks at harvest time. And as is the case with fruit weight, it can be said that some rootstocks such as Citrumelo 1452 increase fruit pulp thickness in the early stages of fruit formation, while the rest of the rootstocks such as Macrophylla and Citrumelo 4475 increase fruit pulp thickness in the later stages of fruit ripening.

*Percentage of juice in relation to fruit weight*

The differences were insignificant among treatments with regard to fruit content of juice as a percentage after 124 days of fruit formation as shown in Table 4, while the trees grafted on Citrumelo 1452 and Sour Orange significantly outperformed in the percentage of juice in relation to fruit weight (38.11 and 37.15%, respectively) the trees grafted on Macrophylla (28.91%) at harvest time.

**Table 4.** Percentage of juice in relation to fruit weight evolution of Clementine Mandarin (strain 88) grafted on different citrus rootstocks

| Rootstock | Fruit content of juice after 124 days of fruit formation (g) | Fruit content of juice after 208 days of fruit formation (g) | Fruit content of juice evolution (%) |
|---|---|---|---|
| Sour Orange | 30.45±11.37$^{a}$ | 37.15±2.28$^{a}$ | 37.14±57.04$^{a}$ |
| Citrumelo 4475 | 34.35±4.88$^{a}$ | 32.62±4.02$^{ab}$ | -2.61±24.12$^{a}$ |
| Citrumelo 1452 | 31.49±10.03$^{a}$ | 38.11±1.78$^{a}$ | 29.97±37.63$^{a}$ |
| Troyer Citrange | 37.52±11.43$^{a}$ | 34.21±3.51$^{ab}$ | -2.02±34.00$^{a}$ |
| Carizzo Citrange | 34.64±14.55$^{a}$ | 33.24±2.13$^{ab}$ | 8.45±42.24$^{a}$ |
| Macrophylla | 38.27±24.56$^{a}$ | 28.91±5.98$^{b}$ | -6.47±39.21$^{a}$ |
| Cleopatra Mandarin | 36.98±16.36$^{a}$ | 34.00±0.52$^{ab}$ | 18.81±83.52$^{a}$ |

Figures that share the same letter on the column have no significant differences, according to the Duncan test ($P < 0.05$).

The results showed insignificant differences among the treatments when studying fruit content of juice evolution. The percentage of juice in relation to fruit weight in the trees grafted on Macrophylla decreased (6.47%), while it increased (29.97%) in the trees grafted on Citrumelo 1452.

These results confirm the results of Cimen (2019) who found that the variation of the rootstock affected fruit content of juice in W. Murcott Mandarin in the stage of fruit ripening. The results of the research do not correspond with Demirkeser et al. (2009) results that showed an insignificant effect of the rootstocks in fruit content of juice in two mandarin varieties (Robinson and Nova). Also, the results do not match with Garcia-Sanchez et al. (2006) results that indicated a decrease in fruit content of juice in Clemenules Mandarin trees grafted on Carrizo Citrange under salinity conditions. However, though the differences among the treatments in fruit content of juice evolution were insignificant, it can be said that Citrumelo 1452 and Sour Orange have an obvious increase in fruit juice content during ripening compared to Macrophylla.

*Evolution of fruit chemical properties of Clementine Mandarin (strain 88) grafted on different citrus rootstocks*

*Proportion of total soluble solids in juice (TSS)*

As shown in Table 5, there were insignificant differences in fruit juice content of total soluble solids among the treatments after 124 days of fruit formation, while the grafted trees on Troyer Citrange were significantly superior in fruit juice content of total soluble solids (13.25%) to the trees grafted on Macrophylla, Sour Orange and Citrumelo 1452 (11.75, 11.75 and 11.25%, respectively) at harvest time.

**Table 5.** Proportion of total soluble solids in juice evolution of Clementine Mandarin (strain 88) grafted on different citrus rootstocks

| Rootstock | Fruit juice content of TSS after 124 days of fruit formation (g) | Fruit juice content of TSS after 208 days of fruit formation (g) | Fruit juice content of TSS evolution (%) |
|---|---|---|---|
| Sour Orange | 9.50±0.58$^{a}$ | 11.75±0.96$^{b}$ | 23.89±10.36$^{ab}$ |
| Citrumelo 4475 | 9.50±1.00$^{a}$ | 12.25±0.50$^{ab}$ | 30.00±14.14$^{ab}$ |
| Citrumelo 1452 | 9.50±0.58$^{a}$ | 11.25±1.26$^{b}$ | 18.33±9.54$^{b}$ |
| Troyer Citrange | 9.75±1.50$^{a}$ | 13.25±0.50$^{a}$ | 38.10±19.58$^{a}$ |
| Carizzo Citrange | 9.75±0.96$^{a}$ | 12.00±1.41$^{ab}$ | 23.21±9.91$^{ab}$ |
| Macrophylla | 8.75±0.50$^{a}$ | 11.75±0.50$^{b}$ | 34.38±2.09$^{ab}$ |
| Cleopatra Mandarin | 9.25±0.50$^{a}$ | 12.50±0.58$^{ab}$ | 35.28±6.31$^{ab}$ |

Figures that share the same letter on the column have no significant differences, according to the Duncan test ($P < 0.05$).

The results of studying fruit juice content of TSS evolution showed that TSS in the trees grafted on Troyer Citrange significantly increased by (38.10%) compared to the trees grafted on Citrumelo 1452 which in TSS increased by (18.33%).

The significant differences in TSS among the treatments at harvest time contradict the results of Demirkeser et al. (2009) and Cimen (2019) that showed there was no effect of the variation of the rootstocks on mandarin fruit content of TSS. The results also contradict both the results of (Ahmed et al., 1980) that indicated the trees grafted on Sour Orange had fruits rich in TSS, and the results of (Fallahi and Rodney, 1992; Garcia-Sanchez et al., 2006) that showed an increase in TSS in mandarin trees grafted on Carrizo Citrange, and the results of (Espinoza-Núñez et al., 2007; Mourão Filho et al., 2007) that showed the highest TSS was in mandarin trees grafted on Swingle Citrumelo and Cleopatra mandarin. It can be concluded that in some rootstocks the effect on TSS appears at harvest time such as Troyer Citrange and Citrumelo 1452.

*Percentage of total acids in fruit juice (TA)*

The results shown in Table 6 revealed that there were insignificant differences in TA among the treatments after 124 and 208 days of fruit formation. The results of studying fruit juice content of TA evolution indicated a significant decrease in TA by 80.99% in the trees grafted on Citrumelo 4475 compared to the trees grafted on Citrumelo 1452 which in TA decreased by 64.91%.



**Table 6.** Percentage of total acids in fruit juice evolution of Clementine Mandarin (strain 88) grafted on different citrus rootstocks

| Rootstock | Fruit juice content of TA after 124 days of fruit formation (g) | Fruit juice content of TA after 208 days of fruit formation (g) | Fruit juice content of TA evolution (%) |
|---|---|---|---|
| Sour Orange | 2.67±0.46$^{a}$ | 0.54±0.20$^{a}$ | -79.55±6.91$^{ab}$ |
| Citrumelo 4475 | 3.36±0.96$^{a}$ | 0.61±0.08$^{a}$ | -80.99±4.79$^{b}$ |
| Citrumelo 1452 | 2.22±0.33$^{a}$ | 0.78±0.35$^{a}$ | -64.91±16.41$^{a}$ |
| Troyer Citrange | 2.60±0.58$^{a}$ | 0.60±0.10$^{a}$ | -75.67±8.17$^{ab}$ |
| Carizzo Citrange | 2.56±1.22$^{a}$ | 0.66±0.18$^{a}$ | -71.55±10.08$^{ab}$ |
| Macrophylla | 3.32±0.55$^{a}$ | 0.68±0.12$^{a}$ | -79.37±3.62$^{ab}$ |
| Cleopatra Mandarin | 3.17±0.78$^{a}$ | 0.58±0.06$^{a}$ | -80.70±6.44$^{ab}$ |

Figures that share the same letter on the column have no significant differences, according to the Duncan test ($P < 0.05$).

The results matched the results of Demirkeser et al. (2009) showing there was no effect of the variation of rootstocks on TA, while the results did not match the results of (Ahmed et al., 1980; Fallahi and Rodney, 1992; Espinoza-Núñez et al., 2007; Mourão Filho et al., 2007; Cimen, 2019) that showed significant differences in mandarin fruit content of TA by using different rootstocks. Anyway, it can be noticed that Clementine fruit content of TA decreased during fruit ripening regardless of the rootstock.

*Maturity coefficient (TSS:TA ratio)*

As shown in Table 7, the highest maturity coefficient (TSS:TA ratio) value was in the trees grafted on Carrizo Citrange (4.29), while the lowest value was in the trees grafted on Macrophylla (2.71) after 124 days of fruit formation. The results for maturity coefficient at harvest time showed that the highest maturity coefficient value was in the trees grafted on Sour Orange (23.26), while the lowest value was in the trees grafted on Citrumelo 1452 (16.37).

**Table 7.** Maturity coefficient evolution of Clementine Mandarin (strain 88) grafted on different citrus rootstocks

| Rootstock | Maturity coefficient after 124 days of fruit formation (g) | Maturity coefficient after 208 days of fruit formation (g) | Maturity coefficient evolution (%) |
|---|---|---|---|
| Sour Orange | 3.63 | 23.26 | 549.45±172.67$^{ab}$ |
| Citrumelo 4475 | 3.05 | 20.47 | 617.73±190.83$^{a}$ |
| Citrumelo 1452 | 4.28 | 16.37 | 278.42±123.40$^{b}$ |
| Troyer Citrange | 3.84 | 22.86 | 522.79±235.17$^{ab}$ |
| Carizzo Citrange | 4.29 | 18.84 | 380.42±181.67$^{ab}$ |
| Macrophylla | 2.71 | 17.84 | 568.40±131.25$^{ab}$ |
| Cleopatra Mandarin | 3.09 | 21.85 | 647.47±192.67$^{a}$ |

Figures that share the same letter on the column have no significant differences, according to the Duncan test ($P < 0.05$).

The results of studying maturity coefficient evolution indicated a significant increase in (TSS:TA ratio) value in the trees grafted on Clementine Mandarin and Citrumelo 4475 by 647.47% and 617.73%, respectively, compared to those grafted on Citrumelo 1452 which in maturity coefficient value increased by 278.42%.

These results match the results of Cimen (2019) which indicated that using rootstock to graft W. Murcott Mandarin affected maturity coefficient value. Also, the results match both the results of Mourão Filho et al. (2007) which showed that the lowest maturity coefficient value was in Sunburst and Fallglo Mandarin trees grafted on Swingle Citrumelo, and the results of Morales et al. (2020) that showed an increase in maturity coefficient value in mandarin trees grafted on Cleopatra Mandarin in the later stages of fruit ripening. Consequently, the results contradict the results of (Demirkeser et al., 2009) that showed an insignificant effect of the rootstock on maturity coefficient value in Robinson and Nova Mandarin fruits and increase in TSS in trees grafted on Sour orange, while they match their results regarding the absence of a significant effect of the different rootstocks on TA.

The significant increase in maturity coefficient evolution as a percentage in the trees grafted on Cleopatra Mandarin and Citrumelo 4475 compared to the trees grafted on Citrumelo 1452 can be explained by the decrease in TA in the trees grafted on Citrumelo 4475 and Cleopatra Mandarin compared to Citrumelo 1452 with insignificant differences in TSS among these treatments at harvest time. Hence, the change in TA has a direct effect on maturity coefficient value, while there is no obvious effect of TSS on that during fruit ripening time.

## Conclusion

From the results of this research it can be concluded that: There is no obvious effect of the rootstock on Clementine Mandarin (strain 88) fruit weight in fruit ripening time though Citrumelo 1452 significantly outperformed the other rootstocks in fruit weight at the early stages of fruit formation. Grafting Clementine Mandarin (strain 88) on Macrophylla rootstock increases peel thickness compared to Troyer Citrange and Cleopatra Mandarin, while grafting on Citrumelo 1452 and Sour Orange increases content of fruit juice compared to Macrophylla at harvest time. Grafting Clementine Mandarin (strain 88) on Troyer Citrange rootstock increases TSS compared to Citrumelo 1452 and Macrophylla during fruit ripening time, and the change in TA plays an obvious role in changing maturity coefficient value compared to the change in TSS.

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# Relationship between seed density, some characteristics of the sowing apparatus and the amount of seed sown

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***Abstract.*** *Grain production provides significant resources for the food industry and animal husbandry. One of the most important moments in the cultivation of cereals is the planting of seeds in the soil. The sowing process is influenced by many factors. This study examines the impact of two such factors: seed density and the length of the sowing apparatus. These factors affect the quantity of seeds sown. Factor analysis demonstrated that changes in seed density exert a more substantial influence on seed quantity alterations. A functional relationship has been determined between the amount of seed sown, the length of the sowing apparatus in the seed box and the density of the crop used.*

**Keywords:** seed density, length of the sowing apparatus, amount of seeds sown

## Introduction

The sowing apparatus is one of the most important working bodies in the construction of the drill. It plays a major role in seed dosing, distribution and delivery (Firsov and Golubev, 2013; Hristova, 2017). It is used to separate a certain number of seeds from the total mass and to form them into a stream with certain parameters. Sowing apparatuses vary in both purpose and design (Klishin, 2003; Krasovskikh and Klishin, 2007). Drum apparatuses are versatile, suitable for sowing various crops.They have a relatively simple construction and easily adapt to different sowing rates. Their main disadvantage, laid down in their principle of operation, is the uneven supply of seeds. The uneven arrangement of the seeds in the field is also affected by the working speed (Maga and Krištof, 2017). Research indicates that the optimal uniformity and the highest biological yield for sowing winter wheat are achieved at a speed of 12 km.h$^{-1}$.

To achieve a specific sowing rate, one can adjust the working length of the sowing apparatus. The amount of seeds sown can also be adjusted by changing its rotation speed. It has been found that high rotation speed damages the seeds. In order to minimize this damage and to ensure greater uniformity of sowing the seeds, it is necessary to choose the possible minimum speed and the maximum working length of the sowing apparatus (Valiev et al., 2013).

The push for improving sowing machines stems from the diverse technological properties of seeds, varied sowing schemes, methods, standards, as well as differing soil-climatic conditions and agronomic requirements. It is considered that the most promising and reliable, with good quality indicators and accurate maintenance of the sowing rate, is the mechanical drive of the sowing apparatus (Antonov and Buchma, 2010; Laryushin et al., 2010; Laryushin and Antonov, 2011). Only those seed properties that significantly influence the sowing process are considered technological (Kapustin, 2012). These include shape, size, density and mass, coefficient of friction, the ability of the seed to withstand certain types of deformation, etc. The shape of the seeds can be ellipsoidal, spherical, lenticular, bean-shaped, pyramidal. The length of cereal seeds varies from 4 (spring wheat) to 18.6 mm (oats), their width - from 1.4 to 4 mm, and thickness - from 1 to 4.5 mm. The shape and size of the seeds influence the process of pouring the seeds from the

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