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The impact of pruning and hand thinning on the productivity and fruit quality of Murcott mandarin

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Abstract

This research sought to evaluate the effects of different pruning and hand thinning practices on the yield, productivity, and fruit quality of the "Murcott" mandarin cultivar. Pruning occurred after winter harvest, removing 25 % or 50 % of vegetative growth. Hand thinning was done in summer by removing 25 % or 50 % of the total fruit per tree. Control trees were left untreated, with no pruning or thinning performed. The results indicated that, while the 50 % pruning treatment resulted in the lowest number of fruits per tree, it had a positive effect on yield, productivity, peel thickness, juice volume, and vitamin C content. The results of hand thinning indicated that, although the control trees produced the greatest number of fruits, the treatments, particularly the 50 % hand thinning, significantly enhanced fruit weight, size, dimensions, titratable acidity (TA), total soluble solids (TSS), and the TA/TSS ratio. Both pruning and hand thinning treatments led to a reduction in percentage of sunburned fruits compared to the control. The results emphasize how these management practices can improve the profitability of "Murcott" mandarin cultivation while aligning with international market standards.

Keywords: *Citrus*, thinning, mandarin, pruning, quality.

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1. Introduction

Citrus is Egypt's premier fruit crop, cultivated extensively and yielding substantial quantities. It also plays a significant role in the country's agricultural exports. This fruit is rich in carbohydrates, proteins, dietary fiber, minerals, and vitamins, with particularly high concentrations of vitamin C. According to the Economic Affairs Sector of the Ministry of Agriculture and Land Reclamation [1], the total area allocated to citrus cultivation in Egypt is estimated at 519,788 feddans, with an annual production of approximately 4,708,427 tons. "Murcott" is a prominent citrus variety that has been extensively cultivated in Egypt in recent decades. While it is highly productive, the tree tends to produce a large quantity of small, low-quality fruits, which negatively impacts consumer preference and marketability. Some citrus cultivars, such as "Murcott," exhibit alternate bearing pattern of fruit production, where trees produce large quantities of smaller fruit during "on" years, followed by significantly reduced yields of larger fruit in "off" years. This pattern appears to be linked to the timing of flower bud differentiation and the crop load. In citrus, flower bud differentiation generally coincides with the onset of new spring growth. An excessive fruit set in one season has been observed to result in no blossom production the following season [2]. Thinning methods are implemented through various agricultural practices, including chemical thinning, hand thinning, and pruning-based thinning [3-5]. Moreover, these techniques enhance the market value of the remaining fruit and helps mitigate the tree's tendency toward biennial bearing [6].

Pruning is a vital horticultural technique in citrus production, with a substantial effect on both yield and fruit quality. The development of a dense canopy and the associated shading effect can lead to a gradual decline in fruit yield. Thus, the systematic removal of excess plant growth by pruning is essential for maintaining sustainable production and enhancing orchard efficiency [7]. Pruning aims to reduce competition for resources between leaves and productive twigs by eliminating unproductive leaves, shoots, and twigs. Varying levels of pruning can yield different outcomes, affecting both tree health and the characteristics of the fruit produced [8]. Fruitlet hand thinning is the precise removal of a portion of the developing fruit before it reaches full maturity on the tree.

Considering the significance of "Murcott" mandarin fruits both in local markets and for export, this study assessed the impact of pruning and hand thinning on

productivity and fruit quality of "Murcott" mandarin, aiming to satisfy the demands of both local and global markets.

2. Materials and Methods

2.1. Plant materials and study location

This study aimed to evaluate the response of "Murcott" mandarin trees (*Citrus sinensis* (L.) Osbeck x *Citrus reticulata* Blanco) to pruning and hand thinning practices, and to examine their effects on productivity and fruit quality. The experiment was conducted over the 2021 and 2022 growing seasons at a private orchard in the Wadi El Natroun district (30°16'12.5"N, 30°13'08.7"E), situated in the El-Behera governorate. This study utilized five-year-old "Murcott" mandarin trees grafted onto 'Volkamer Lemon' rootstock (*Citrus volkameriana*). All trees were spaced at 4 x 6 meters, planted in sandy soil, and irrigated using a drip irrigation system. In each season, trees of similar age and size were carefully selected, ensuring they were in their "on" year of production. All trees were provided with the recommended monthly doses of irrigation and fertilization, as outlined in Figure 1.

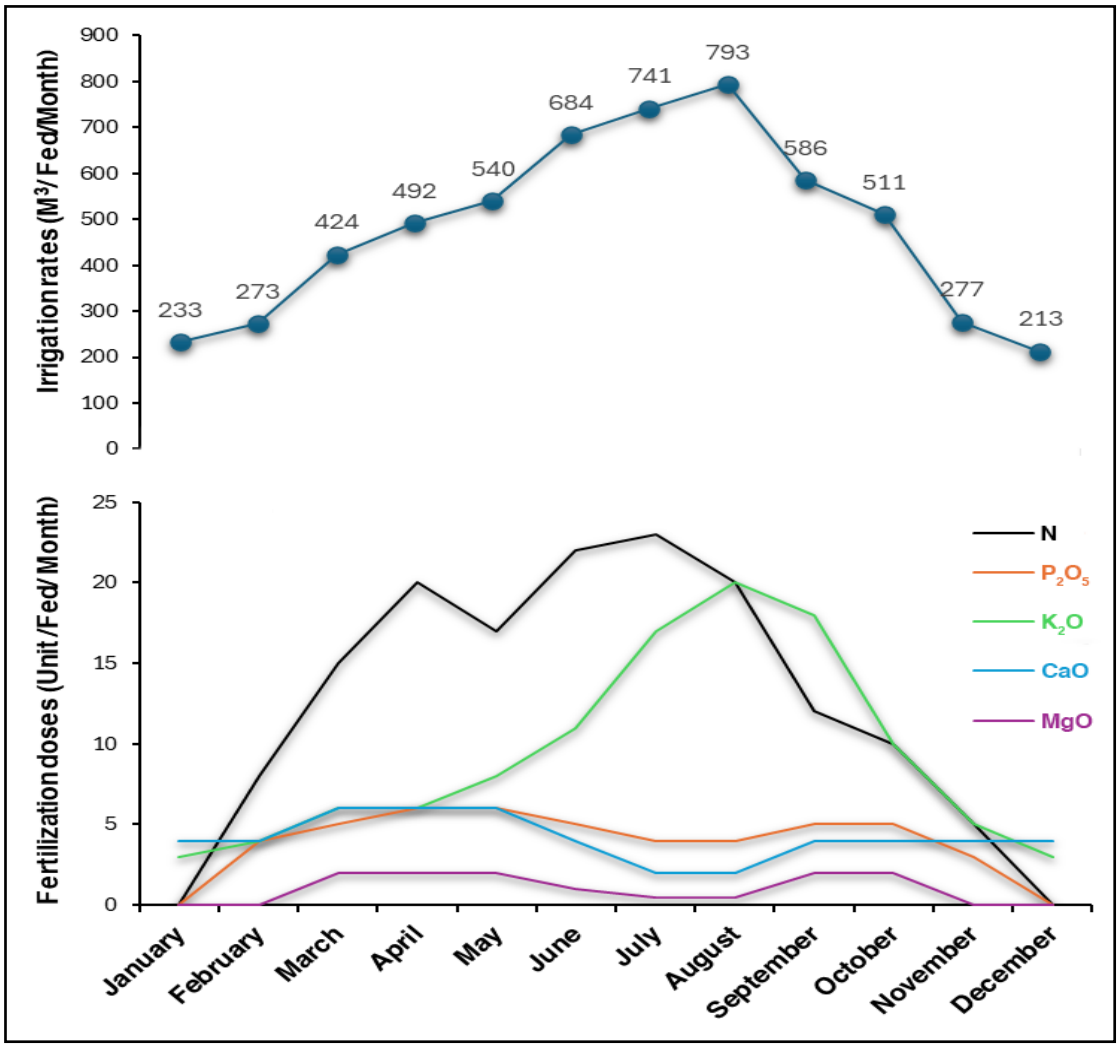

Figure 1. The irrigation and fertilization practices adopted in this study for the "Murcott" mandarin farm.

2.2. Treatments

Pruning (Pr) was performed in the winter directly after the crop harvest, specifically on February 25 for both growing seasons. This process included the removal of 25 % (Pr 25 %) or 50 % (Pr 50 %) of the trees' vegetative growth, especially the previous year's growth. Hand thinning (H.Th) was performed on July 10 in both seasons, after the physiological fruit drop stage. The thinning percentages were determined by first calculating the total number of fruits on the tree and then removing either 25 % (H.Th 25 %) or 50 % (H.Th 50 %) of the fruit. Control trees were those that were neither pruned nor thinned. Pruning and hand thinning experiments were conducted independently, using 3 Murcott mandarin trees per treatment, with a total of 9 trees for each experiment.

2.3. Data recorded

Upon the completion of each of the two seasons studied (with harvest dates on January 15 for the 2021

season and January 21 for the 2022 season), the following parameters were determined: the number of fruits per tree, the percentage of sunburned fruits per tree, fruit weight (in grams), yield (in kilograms per tree), and productivity (in tons per feddan). Subsequently, thirty fruits from each treatment (10 fruits per replicate) were randomly selected to assess their physical and chemical characteristics. These included fruit length (cm), fruit diameter (cm), length-to-diameter (L/D) ratio, fruit size (cm^3), peel thickness (mm), and juice volume (ml). Titratable acidity (TA %) was determined according to A.O.A.C. [9] methods, while total soluble solids (TSS %) were measured using a refractometer at room temperature. Then, the TSS/TA ratio was calculated. Also, vitamin C content (mg/100g) was analyzed following the A.O.A.C. [10] methods.

2.4. Statistical analysis

The experiment was structured with three replicates for each treatment, consisting of three trees per replicate, utilizing a completely randomized design. Data collected for the years 2021 and 2022 were combined and statistically analyzed using two-way analysis of variance (ANOVA) implemented in R statistical software, version 4.4.1 [11]. The results are presented as the average of the two combined seasons. Differences in significance were assessed using the Duncan range test at a 0.05 significance level [12]. Pearson's correlation coefficient was calculated to identify relationships between the measured parameters in the study.

3. Results and Discussion

3.1. Effect of pruning and hand thinning on yield components of "Murcott" trees

Figure 2A illustrates a significant difference ($P \geq 0.05$) among the treatments regarding the total number of fruits remaining on the "Murcott" trees at harvest. The control group exhibited the highest significant ($P \leq 0.05$) fruit number (892.41), followed by the 25 % pruning and 25 % hand thinning treatments (641.50 and 528.83, respectively), while the 50 % pruning and 50 % hand thinning treatments resulted in the lowest number of fruits at harvest (431.33 and 337, respectively). Although the control treatment had the highest number of fruits, it recorded the lowest significant ($P \leq 0.05$) fruit weight (118 g), while the 50 % hand thinning treatment showed the highest significant ($P \leq 0.05$) fruit weight among all treatments, measuring 231.33 g (Figure 2B). Similarly, as illustrated in Figure 2C, the treatment involving 25 % hand thinning produced the highest significant ($P \leq 0.05$) yield per tree (122.10 kg). Conversely, the treatment with 50 % tree pruning yielded the lowest significant ($P \leq 0.05$) yield per tree at 65.72 kg, in comparison to the other treatments. As a result, these findings were mirrored in the productivity per feddan, where a similar trend was observed across all treatments evaluated in the study (Figure 2D).

Fruit thinning is a widely practiced technique in citrus and other fruit orchards, aimed at regulating crop load. This practice is essential for maximizing fruit size and enhancing quality characteristics, including color, shape, and overall marketability, while also maintaining the health and structural integrity of the tree. Moreover, thinning contributes to increased crop value and helps ensure regular blooming, which is important for reducing the impact of alternate bearing cycles [13]. In this study, all treatments reduced the tree's yield and thus productivity compared to control, except for the 25 % pruning treatment, which resulted in an increase in yield and productivity, which is attributed to the noticeable increase in the fruit number and weight. These findings align with observations made by other researchers who have investigated the effects of both pruning and hand thinning across various horticultural species [14, 3, 15, 16]. A field experiment was conducted to evaluate the effects of fruit hand thinning at 10 %, 20 %, and 30 % intensity during the pea stage on the growth, yield, fruit grading, and quality of nectarines. The results demonstrated that hand thinning significantly enhanced fruit size, weight, and the proportion of higher-grade fruits [17].

Additionally, a study with similar findings examined the effects of pruning on the quality of Siamese citrus fruits. The treatment that involved trimming young shoots, diseased twigs, and shaded leaves improved fruit quality, resulting in a harvest weight of 3638.77 g per tree, a fruit weight of 173.58 g, and total dissolved solids of 9.63 °Brix [18]

3.2. Effect of pruning and hand thinning on the percentage of sunburned fruits

Figure 3 indicates that the control group exhibited the highest significant ($P \leq 0.05$) percentage of sunburned fruits per tree, with a value of 4.53 %. However, no significant differences were observed among the other treatments. The percentage of sunburned fruits is one of the important criteria that indicates the quality of the fruits, and thus their marketing and export value. This study demonstrated that increased levels of hand thinning or pruning led to a reduction in sunburned fruits. This can be attributed to the fact that during pruning or hand thinning, limbs or fruits that will be directly exposed to sunlight are usually selectively removed, leaving behind only those protected from direct sunlight within the tree canopy.

Sunburn is a major concern in arid and semi-arid regions with intense solar exposure. In these areas, the high occurrence of fruit sunburn is often linked to elevated plant water stress caused by heat and drought.

Thin-skinned fruits are especially prone to damage, significantly affecting their quality and market value, though other types of fruit can also be impacted [19]. These findings align with the results reported by other researchers studying mandarin fruit [20, 3, 21].

Also, the occurrence and intensity of sunburn are influenced by climatic factors, cultivar selection, hormonal balance, nutritional status, and soil moisture levels [22]. The damage resulting from sunburn varies across different varieties, ranging from 0.9 to 19.13 % [23].

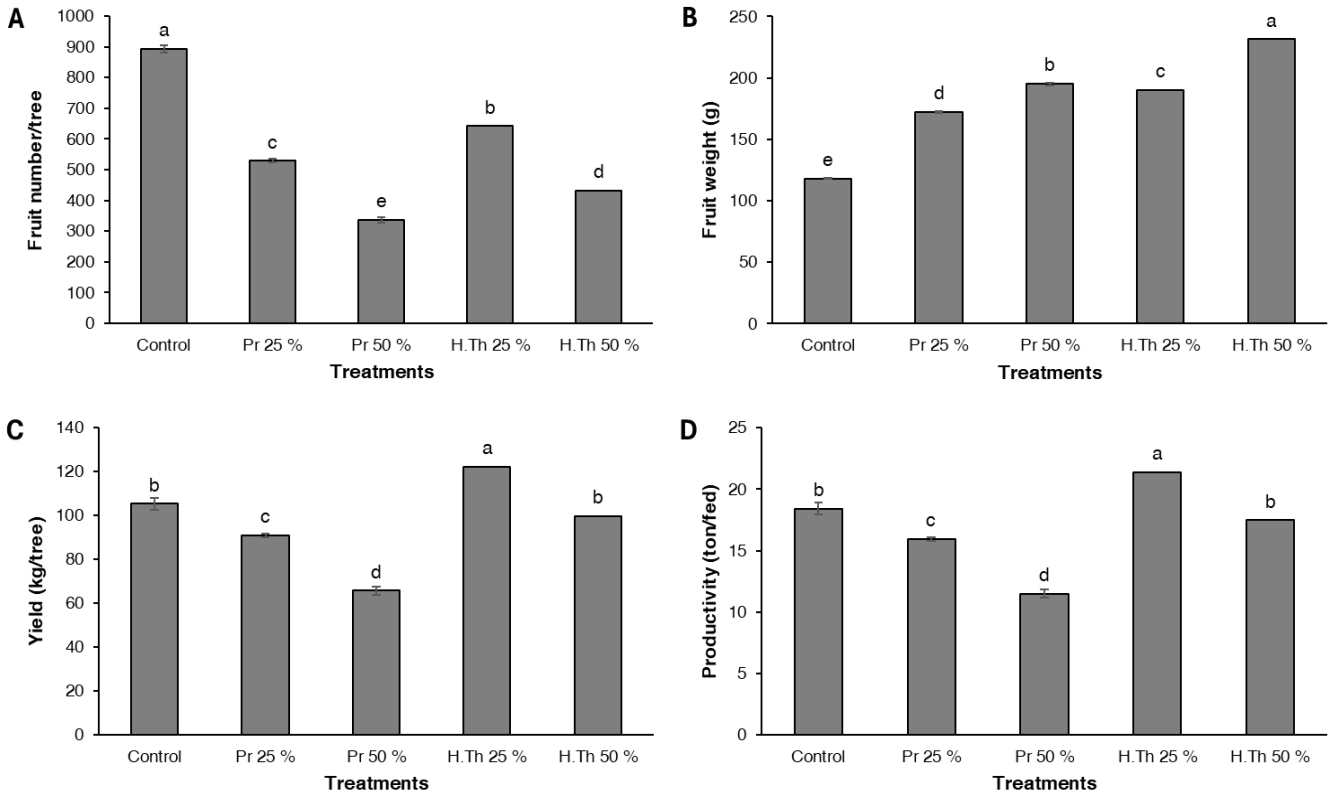

Figure 2. Impact of pruning and hand thinning treatments on A) fruit number per tree, B) fruit weight, C) yield, and D) productivity of "Murcott" trees over the two combined seasons. Different lower-case letters indicate statistical differences ($P \leq 0.05$, Duncan). Vertical bars show the ± SD.

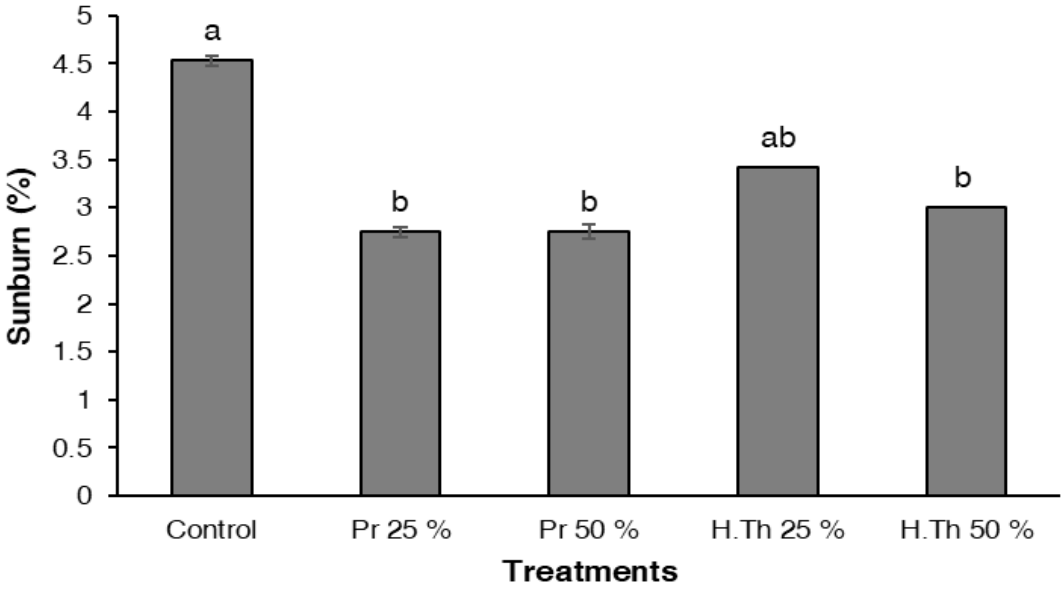

Figure 3. Impact of pruning and hand thinning treatments on the percentage of sunburned fruits per tree of "Murcott" trees over the two combined seasons. Different lower-case letters indicate statistical differences ($P \leq 0.05$, Duncan). Vertical bars show the ± SD.

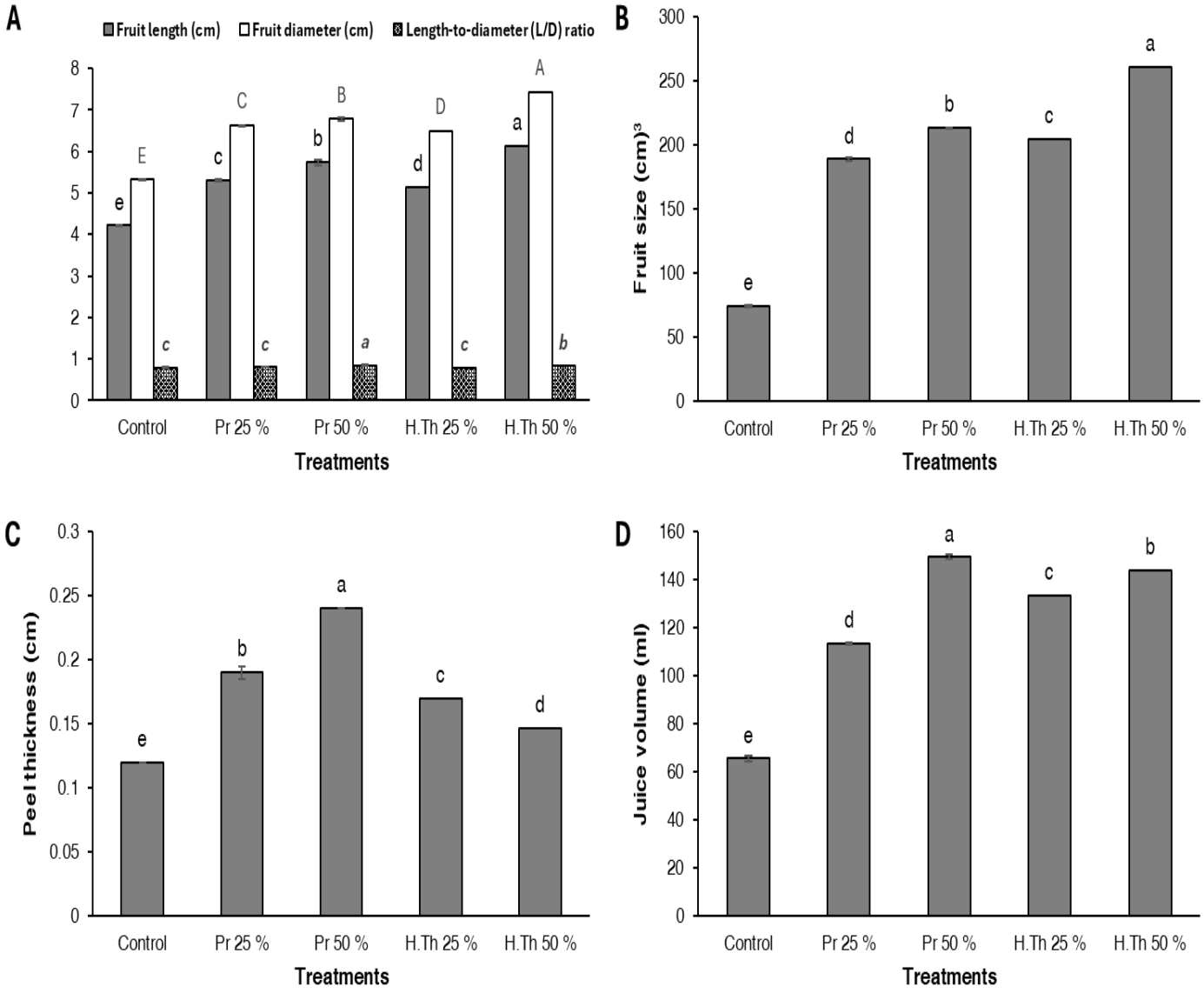

Figure 4. Impact of pruning and hand thinning treatments on A) fruit dimensions, B) fruit size, C) peel thickness, and D) juice volume of "Murcott" trees over the two combined seasons. Different lower-case letters indicate statistical differences ($P \leq 0.05$, Duncan). In Figure 4A, different lowercase letters indicate statistical differences in fruit length, while uppercase letters are used for diameter, and bold italic lowercase letters represent the L/D ratio. The vertical bars show the ± SD.

3.3. Effect of pruning and hand thinning on physical fruit characteristics

Figure 4A illustrates the significant effects of different treatments on fruit length (L), fruit diameter (D), and the length-to-diameter ratio (L/D). Concerning fruit length, the 50 % hand thinning treatment resulted in the greatest length (6.13 cm), while the shortest length (4.21 cm) was recorded in the control group. Likewise, it was observed that the fruit diameter was also significantly ($P \leq 0.05$) affected between the different treatments under this study, as the 50 % hand thinning treatment recorded the highest significant ($P \leq 0.05$) fruit diameter (7.41 cm), while the lowest significant ($P \leq 0.05$) diameter of the fruit was recorded in the control treatment (5.31 cm). Moreover, it is noted from the fruit length-to-diameter (L/D) ratio that the 50 % pruning treatment gave the highest significant ($P \leq 0.05$) ratio (0.84), followed by the 50 % hand thinning treatment (0.82), while there were no significant differences between the rest of the treatments in this ratio (Figure 4A).

The fruit size was markedly influenced by the various treatments (Figure 4B), with the 50 % hand thinning treatment yielding the largest size (260.66 cm^3), followed by the 50 % pruning treatment (213.33 cm^3). In contrast, the smallest size was observed in the control fruit (74.00 cm^3). Also, significant differences in fruit peel thickness were observed across the treatments (Figure 4C). The 50 % pruning treatment resulted in the greatest peel thickness (0.24 cm), followed by the 25 % pruning treatment (0.19 cm). The control treatment exhibited the lowest peel thickness, with a value of 0.12 cm. It is also observed from Figure 4D that the volume of fruit juice in the 50 % pruning treatment gave the highest significant ($P \leq 0.05$) volume of juice (149.33 ml), followed by the 50 % hand thinning treatment (144.00 ml), while the control treatment achieved the lowest significant ($P \leq 0.05$) volume of fruit juice (65.50 ml).

The removal of excess developing fruitlets has also been reported to enhance fruit size in citrus [24, 15, 16, 4]. Moreover, hand thinning markedly enhanced fruit development, resulting in a significant increase in both transverse and longitudinal diameters relative to the control group. This growth stimulation became apparent 15 days after thinning and led to a considerable rise in average fruit weight by the conclusion of the study [13].

3.4. Effect of pruning and hand thinning on chemical fruit characteristics

As can be seen from Figure 5A, no significant differences in titratable acidity (TA) percentage were observed among the treatments, except for the 50 % hand thinning treatment. This treatment exhibited the lowest acidity percentage in "Murcott" fruits, which was significantly lower compared to the other treatments. In terms of total soluble solids (TSS) percentage, the 50 % hand thinning treatment resulted in the lowest significant ($P \leq 0.05$) value (11.65 %), followed by the 50 % pruning treatment (14.02 %). Both the control and the 25 % hand thinning treatments recorded the highest TSS values (14.35 and 14.33 %, respectively), with no significant differences observed between them. With respect to the TSS to TA ratio, the highest value was observed in the 50 % hand thinning treatment, followed by the control and 25 % hand thinning treatments.

The lowest ratios were recorded in the two pruning treatments (Figure 5A). Figure 5B indicates that the 50 % pruning treatment significantly ($P \leq 0.05$) enhanced the vitamin C content of "Murcott" fruits, reaching 33.23 mg/100 g. In contrast, the control treatment exhibited the lowest vitamin C content, with a value of 26.16 mg/100 g. This is consistent with findings from Salama *et al*. [25], who reported that pruning "Olinda" orange trees raised ascorbic acid content. Similarly, Baghdady [26] found that removing 75 % of 2-year-old branches resulted in the highest Vitamin C levels in "Balady" mandarins. The rise in ascorbic acid content may be associated with enhanced nutrient availability, especially potassium, as suggested by Rekha *et al*. [27] to slow ascorbic acid oxidation, allowing greater accumulation in fruits. Reducing the number of fruit either by hand thinning or pruning can increase fruit size, which may lead to a lower yield but results in enhanced citrus fruit quality and improved physico-chemical characteristics [28, 14, 29-31, 15, 16, 32, 18, 13]. Thinned fruits showed significantly higher levels of total soluble solids (TSS), titratable acid (TA), and vitamin C compared to the control group, indicating better sugar accumulation and increased nutritional value.

The study further found that hand thinning increased the expression of sugar transporter genes, suggesting enhanced sugar movement from leaves to fruit. In addition, hand thinning influenced hormone synthesis, particularly auxins and gibberellins, which are critical for fruit development and quality [13]. Furthermore, a study assessed the impact of pruning on 5-year-old "Murcott" and "Fremont" mandarin trees (*Citrus reticulata* Blanco). The trees underwent pruning to retain 25 % (light), 50 % (moderate), or 75 % (heavy) of the previous year's shoots, while a control group was left unpruned. Findings revealed that "Fremont" produced a higher fruit yield than "Murcott." Light pruning (25 %) led to a significant yield increase compared to the control, whereas moderate pruning (50 %) achieved the highest overall yields. Moreover, 'Fremont' demonstrated greater total soluble solids (TSS) and TSS/acid ratio than "Murcott." All pruning treatments positively affected TSS and TSS/acid ratios in both cultivars, suggesting that light and moderate pruning enhanced both yield and fruit quality [32].

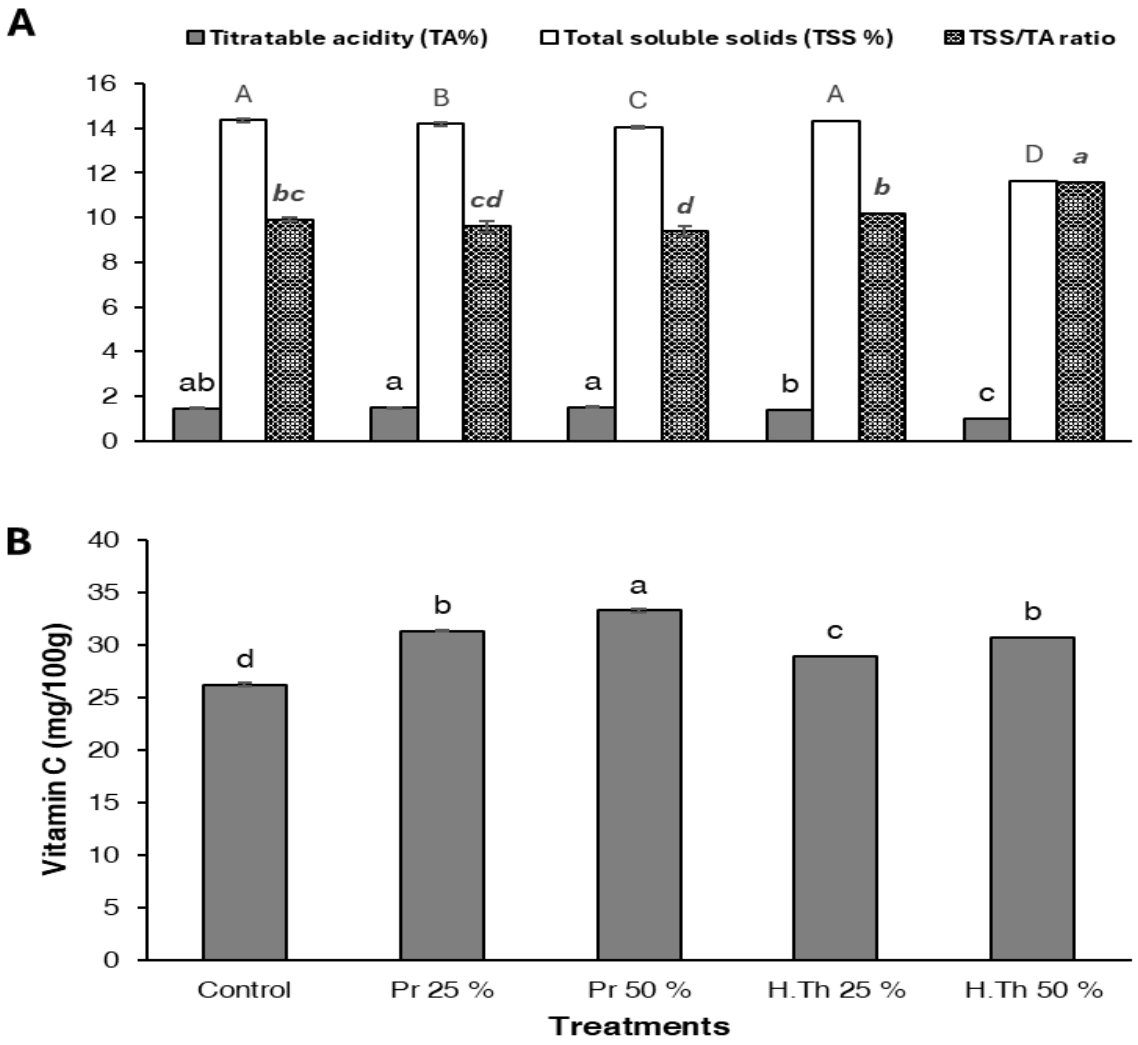

Figure 5. Impact of pruning and hand thinning treatments on the chemical fruit characteristics (TA, TSS, and TSS/TA ratio (A); Vitamin C (B)) of "Murcott" trees over the two combined seasons. Different lower-case letters indicate statistical differences ($P \leq 0.05$, Duncan). In Figure 5A, different lowercase letters indicate statistical differences in titratable acidity (TA %), while uppercase letters are used for total soluble solids (TSS %), and bold italic lowercase letters represent the TSS to TA ratio. Vertical bars show the ± SD.

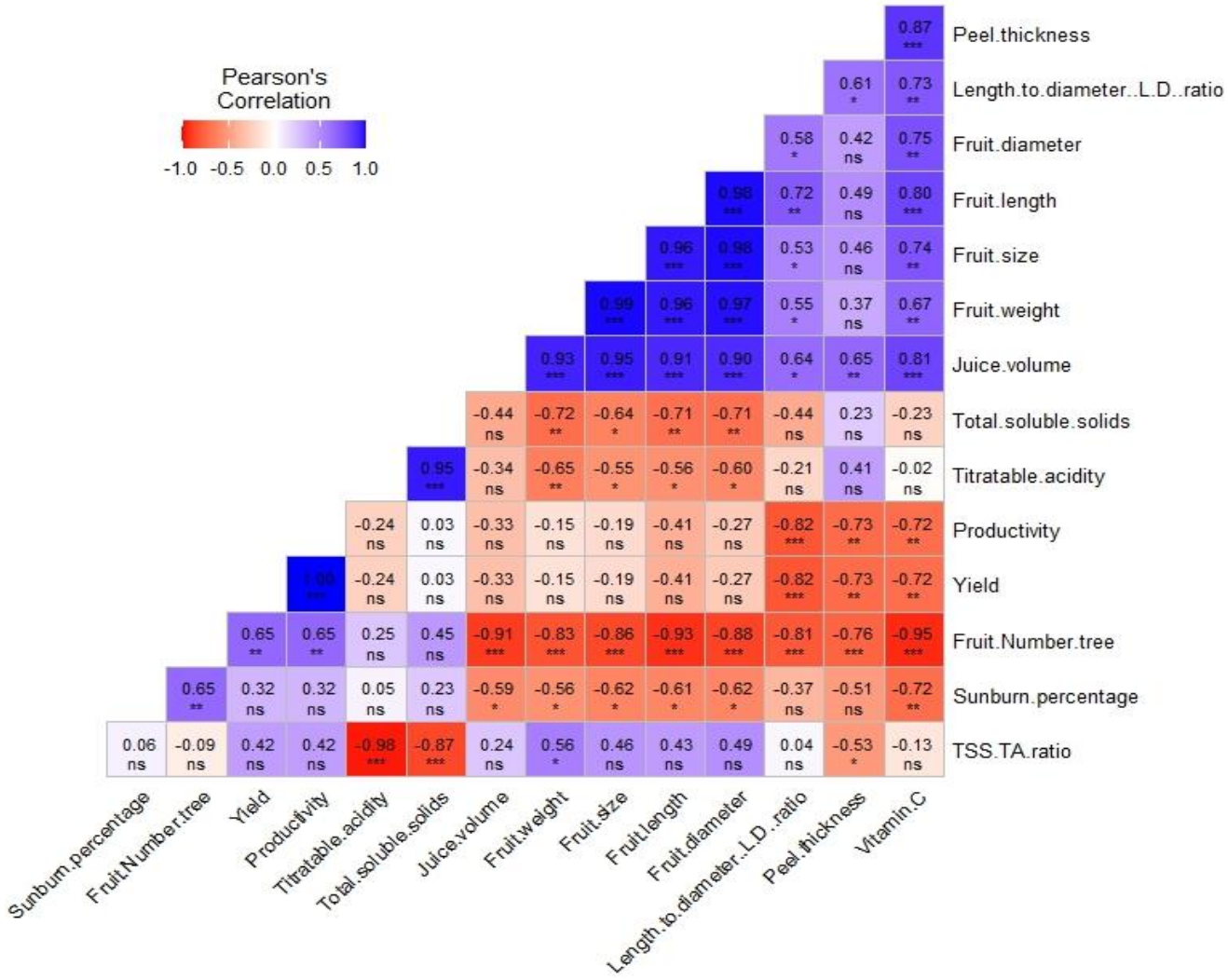

Figure 6: Pearson's correlation coefficient analysis across all treatments were used to illustrate the relationships between the studied variables of "Murcott" mandarins under pruning and hand thinning treatments. R is presented in different colors; the legend shows the color range of different R values with * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$ as indicators of statistical significance.

3.5. Correlation analysis

Figure 6 revealed a significant positive correlation between fruit length, diameter, size, weight, and juice volume. Similarly, tree yield showed a strong positive correlation with productivity. In contrast, a significant negative correlation was observed between the number of fruits per tree and fruit characteristics such as length, diameter, diameter-to-length ratio, size, weight, and juice volume.

4. Conclusion

The study found that both pruning and hand thinning practices enhanced yield, productivity, and fruit quality of the "Murcott" mandarin cultivar. For optimal outcomes, either a 50 % pruning or 50 % hand thinning level is recommended. This will enable growers to meet international standards and contribute to the expansion of global citrus exports.

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Conflict of interest

The authors declare that they have no conflict of interest.

References

[1] The Economic Affairs Sector of the Ministry of Agriculture and Land Reclamation (2022). Bulletin of The Agricultural Statistics, part II, pp 378.

[2] S. P. Monselise & E. E. Goldschmidt. (1982). Alternate bearing in fruit trees. Horticultural reviews, 4(1), 128-173.

[3] Ouma, G. (2012). Fruit thinning with specific reference to citrus species: A review. Agric. Biol. JN Am, 3(4), 175-191. DOI:10.5251/abjna.2012.3.4.175.191.

[4] M. Umar, S. Ahmad, S. T. A. Haider & S. Naz. (2019). Effect of pruning to improve yield and fruit quality of 'Kinnow' mandarin plants under high density plantation. J. Hortic. Sci. Technol, 2, 85-89.

[5] W. Shafqat, N. Fatima, M. J. Jaskani, S. Ikram, R. Amen, W. S. Chattha, M. S. Haider & R. S. Ferrarezi. (2023). Fruit thinning chemical agents improves fruit size and quality in 'Kinnow' mandarin (*Citrus Reticulata* Blanco)-Rutaceae. Pak. J. Bot., 55(6), 2381-2392.

[6] E. Stover, S. Ciliento, M. Ritenour & C. Counter. (2002). NAA thinning of 'Murcott': comparison of small plot and commercial harvest data. In Proceedings of the Florida State Horticultural Society, (115) 287-291.

[7] A. Ghosh, K. Dey, N. Bhowmick, P. S. Medda & S. K. Ghosh. (2016). Impact of different pruning severity and nutrient management on growth and yield of lemon cv. Assam Lemon (*Citrus limon* Burm.). Vegetos, 29:1, 2-8. DOI:http://dx.doi.org/10.4172/2229-4473.1000106.

[8] P. Chueca, G. Mateu, C. Garcerá, A. Fonte, C. Ortiz & A. Torregrosa. (2021). Yield and economic results of different mechanical pruning strategies on "Navel Foyos" oranges in the Mediterranean Area. Agriculture, 11(1), 82. DOI:https://doi.org/10.3390/agriculture11010082

[9] A.O.A.C., Association of Official Analytical Chemists, & Association of Official Agricultural Chemists (US). (2000). Official method of analysis of association of official analysis chemists.16th Ed. Association of Official Analytical Chemists. Washington. D.C., U.S.A.

[10] A.O.A.C., Association of Official Analytical Chemists, & Association of Official Agricultural Chemists (US) (1990). Methods of analysis 13th ed., Association of official agricultural chemical Washington D.C. U.S.A.

[11] R. Core Team. (2023). R: A Language and Environment for Statistical Computing; R Foundation for Statistical Computing: Vienna, Austria. Available online: https://www.R-project.org/.

[12] D. B. Duncan. (1955). Multiple range and multiple F tests. Biometrics, 11, 1–42. https://doi.org/10.2307/3001478.

[13] L. I. U. Cong, D. X. Li, X. B. Huang, F. Q. Zhang, Z. Z. Xie, H. Y. Zhang & J. H. Liu. (2022). Manual thinning increases fruit size and sugar content of Citrus reticulata Blanco and affects hormone synthesis and sugar transporter activity. Journal of Integrative Agriculture, 21(3), 725-735.

[14] R. A. Mostafa & H. A. Abdel-Aal. (2009). Effect of manual fruit thinning on alternate bearing, yield and fruit quality of Balady Mandarin trees. Assiut Journal of Agricultural Sciences, 40(1), 38-50. 10.21608/ajas.2009.268640.

[15] B. M. Górriz, I. P. Castillo & A. Torregrosa. (2014). Effect of mechanical pruning on the yield and quality of "Fortune" mandarins. Spanish Journal of Agricultural Research, 12(4), 952-959. DOI:http://dx.doi.org/10.5424/sjar/2014124-5795.

[16] B. N. Samra & A. M. Shalan. (2014). Effect of hand thinning on yield and fruit quality of "Murcott" Tangor. Journal of Plant Production, 5(8), 1433-1440. DOI:10.21608/jpp.2014.64668.

[17] J. S. Chandel & J. Singh. (2015). Effect of chemical and hand thinning on growth, yield and fruit quality of nectarine (*Prunus persica* Batsch var. nucipersica). Indian Journal of Horticulture, 72(1), 28-32.

[18] N. K. A. Astiari, N. P. A. Sulistiawati, I. B. K. Mahardika & I. N. Rai. (2019). Improving the quality fruit of citrus cv. Siam out off-season through the application of fertilization and pruning. In Journal of Physics: IOP Publishing, Conference Series, 1402, 5, p. 055088. DOI:10.1088/1742-6596/1402/5/055088.

[19] J. Rodriguez, A. Anoruo, J. Jifon & C. Simpson. (2019). Physiological effects of exogenously applied reflectants and anti-transpirants on leaf temperature and fruit sunburn in citrus. Plants, 8(12), 549. DOI:https://doi.org/10.3390/plants8120549.

[20] M. A. Myhob, L. F. Guindy & S. E. Salem. (1996). Influence of sunburn on Balady mandarin fruits and its control. Bull. Fac. Agric. Univ. Cairo, 47, 457-470.

[21] M. M. El-Tanany, A. M. A. Kheder & H. R. Abdallah. (2019). Effect of some treatments on reducing sunburn in Balady Mandarin fruit trees (*Citrus reticulata*, Blanco). Middle East J. Agric. Res., 8(3), 889-897.

[22] L. Schrader, J. Zhang & J. Sun. (2003). Environmental stresses that cause sunburn of apple. Acta Hort., 618, 397-405.

[23] G. Singh, V. Nath, S. D. Pandey, P. K. Roy & H. S. Singh. (2012). The Litchi, Food and Agricultural Organization of the United Nations, New Delhi, India. 76-78.

[24] J. L. Guardiola & A. García-Luis. (2000). Increasing fruit size in Citrus. Thinning and stimulation of fruit growth. Plant growth regulation, 31, 121-132.

[25] B. L. Salama, A. F. Abou-Hadid, N. Abdelhamid & M. Z. El-Shinawy. (2018). Effect of pruning pattern and soil mulching on yield and quality of keitt mango in new reclaimed lands. Arab Universities Journal of Agricultural Sciences, 26(1), 147-159. DOI:10.21608/ajs.2018.13900

[26] G. A. Baghdady. (1993). Effect of Pruning on Yield and Fruit Quality of Balady Mandarin. Ann. Agric. Sc. Moshtohor, 13, 1158-1166.

[27] C. Rekha, G. Poornima, M. Manasa, V. Abhipsa, J. P. Devi, H. T. V. Kumar & T. R. P. Kekuda. (2012). Ascorbic acid, total phenol content and antioxidant activity of fresh juices of four ripe and unripe citrus fruits. Chemical Science Transactions, 1(2), 303-310. DOI:10.7598/cst2012.182.

[28] S. Ahmad, Z. A. Chatha, M. A. Nasir, A. B. D. U. L. Aziz, N. A. Virk & A. R. Khan. (2006). Effect of pruning on the yield and quality of Kinnow fruit. J. Agric. Soc. Sci., 2(1), 51-53. 1813–2235/2006/02–1–51–53.

[29] B. Yildirım, T. YeşİloğIu, M. Incesu, M. Kamiloğlu, F. Özgüven, O Tuzcu & Y. A. Kacar. (2010). The effects of mechanical pruning on fruit yield and quality in 'Star Ruby' grapefruit. J. Food Agric. Environ., 8, 834–838.

[30] F. Intrigliolo & G. Roccuzzo. (2011). Modern trends of Citrus pruning in Italy. Advances in Horticultural Science, 25(3), 187-192.

[31] A. Din, M. Asghar, S. Parveen & M. Azhar Ali. (2012). Evaluation of Kinnow mandarin as influenced by pre-harvest management practices. Journal of Agricultural Research, (03681157), 50(3).

[32] A. E. Hamdy (2018). Effect of pruning severity on yield and fruit quality of two mandarin cultivars. In VI International Symposium on Tropical and Subtropical Fruits 1216 (pp. 135-144). DOI:10.17660/ActaHortic.2018.1216.17