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Pruning Boosts Growth, Yield, and Fruit Quality of Old Valencia Orange Trees: A Field Study

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Abstract: Pruning is an essential practice that helps control branch growth, optimize fruit size, and enhance fruit tree productivity. This study focused on 'Valencia' orange trees, which had experienced a decline in productivity after being cultivated on reclaimed lands for several years. The aim was to explore the impact of pruning intensity on vegetation growth, fruit yield, productivity, and fruit quality in these orange trees. The study involved 35-year-old 'Valencia' orange trees, which were subjected to four different levels of pruning. The pruning treatments included: T1—no pruning (control group), T2—light pruning (removal of 25% of main branches), T3—moderate pruning (removal of 50% of main branches), and T4—heavy pruning (removal of 75% of main branches). Each season, these pruning measures were consistently carried out on 15 February. The results indicated that the severity of pruning directly influenced vegetative growth parameters, such as shoot length and leaf area. As the pruning intensity increased, so did the growth of the vegetation. However, the overall volume of the tree's canopy decreased compared to the control group. These findings provide insights into the relationship between pruning practices and the growth and productivity of 'Valencia' orange trees. The highest fruit yields were observed when pruning was carried out at a severity level of 75%, followed by 50 and 25%. These pruning treatments had a positive impact on various aspects of fruit quality, including weight, size, firmness, juice content, TSS (°Brix), TSS/acid ratio, and vitamin C content. Additionally, pruning contributed to a greater fruit yield per tree and an overall increase in the yield percentage. In essence, the findings suggest that pruning performed at different severity levels in February effectively promotes vegetation growth and enhances the physical and chemical properties of 'Valencia' orange trees. Notably, it resulted in a nearly 20% rise in fruit yield compared to the control group.

Keywords: *Citrus sinensis* L.; decline in productivity; correct pruning; tree canopy; yield; vitamin C

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1. Introduction

In Egypt, citrus is the most widely cultivated fruit crop [1] and ranks first among economically important fruit crops worldwide [2]. The 'Valencia' orange is considered one of the most important oranges in the world and is said to be of Spanish origin [3]. The trees are medium-sized, reaching 3 m in height, and the fruits are medium to large, seedless or with seed traces, hard to peel, and have a sweet flavor [4]. The overall harvested area is 135,962.5 ha, with a total production of fresh orange fruits in Egypt around 3,438,030 t, of which 1,600,000 t are exported [5]. 'Valencia' orange (*Citrus sinensis* L.) (Osbeck) is considered the most important cultivar for exporting purposes in the Egyptian citrus industry [6]. Valencia orange trees were grown many years ago, and as a result, the trees suffer from a decline in productivity in the newly reclaimed lands after a certain number of years of plantation [7]. In fact, due to aging, light does not penetrate the tree canopies, thus impeding inflorescence and fruit setting around the surface of the tree [8]. Hence, to maintain high production of optimum-sized, good-quality fruit, canopy management is an effective strategy [9]. The reason why many fruit crops produce such low yields may be due to improper spacing. Planting density is made so that different managerial or biological aspects correlate with one another in order to improve economic outcomes. As a result, more trees may be planted in a smaller area [10]. Accordingly, only limited research has been carried out on the pruning severity of 'Valencia' oranges grown under high density. Severe pruning is used as a last resort to restore the plant to its previous state [11]. To revive the plants, skeletonization (heavily trimming the plant's framework with thick branches) is utilized [12]. It is attempted after top working, frame working, and pruning [13]. In any case, top working and pruning may be used to prevent citrus orchard decline if the extent of the decline, age of the tree, soil and climatic conditions, and other factors are favorable [14,15].

Citrus-tree pruning has long been known to improve fruit size and quality, avoid excessive fruiting, promote vegetative growth, improve light penetration into the tree canopy, and lengthen the tree's lifespan [16]. Pruning procedures in citriculture are critical for maintaining plant health and achieving an optimal balance of vegetative and reproductive activity [17]. Pruning at severe levels increased the shoot length and leaf area, and decreased the plant height in 'Nagpur' mandarin trees [18]. Pruning of the 'Keitt' mango (removing 15, 30, and 45 percent of the tree canopy) improved vegetative growth when compared to unpruned trees [19]. All pruning treatments resulted in a significant increase in leaf area and fruit yield per tree and fruit drop was minimized as a result of the severe pruning [20]. A proper pruning schedule is required to keep the 'Valencia' tree [21] at a suitable size to avoid the following issues: (a) in an orange orchard, the height and canopy shape of mature trees will not be uniform [21]; (b) the branches will cluster, and internal branches may perish due to a lack of sunshine [22]. The tree will only grow fruit on the canopy's surface, and it will become less prolific over time [23]. Fruit quality is generally poor, and trees do not always produce fruit each year [24]. Based on the passage above, the objective of this study was to investigate the effect of different levels of pruning on the yield and quality of 'Valencia' orange trees. The goal was to develop appropriate pruning techniques to maximize output and preserve fruit quality. Another aim of the research was to promote tree openness, which enhances the growth of new branches that bear fruit in the subsequent season. By reducing tangled branches that do not produce fruit, this also helps to increase overall yield.

2. Materials and Methods

2.1. Experimental Site

The study was carried out over two consecutive seasons of 2019/2020 and 2020/2021 on Valencia orange trees (*Citrus sinensis* L.) (Osbeck) that were 35 years old. These orange trees were cultivated in sandy soil in a private orchard located in Wadi Elmollak, Ismailia Governorate, Egypt (30°35′ N, 32°14′ E). The climate of Ismailia Governorate, Egypt, can be observed in Figure 1 and is classified as Mediterranean, with an average annual temperature of 21.3 °C and an annual rainfall of 26 mm. The trees were grafted onto Volkamer lemon (*Citrus volkameriana* Ten. & Pasq.) rootstock, which is compatible with Valencia orange trees. They were planted with a spacing of 3 m × 5 m, resulting in 666 trees per hectare. Drip irrigation using surface methods was employed in the research, with each tree having 8 adjustable discharge emitters that released 8 L of water per hour through 2 irrigation lines. The soil in the study area consists mainly of sand, accounting for 94.72%. The objective of this study was to investigate how different pruning severities affect the production and quality of fruit in Valencia orange trees.

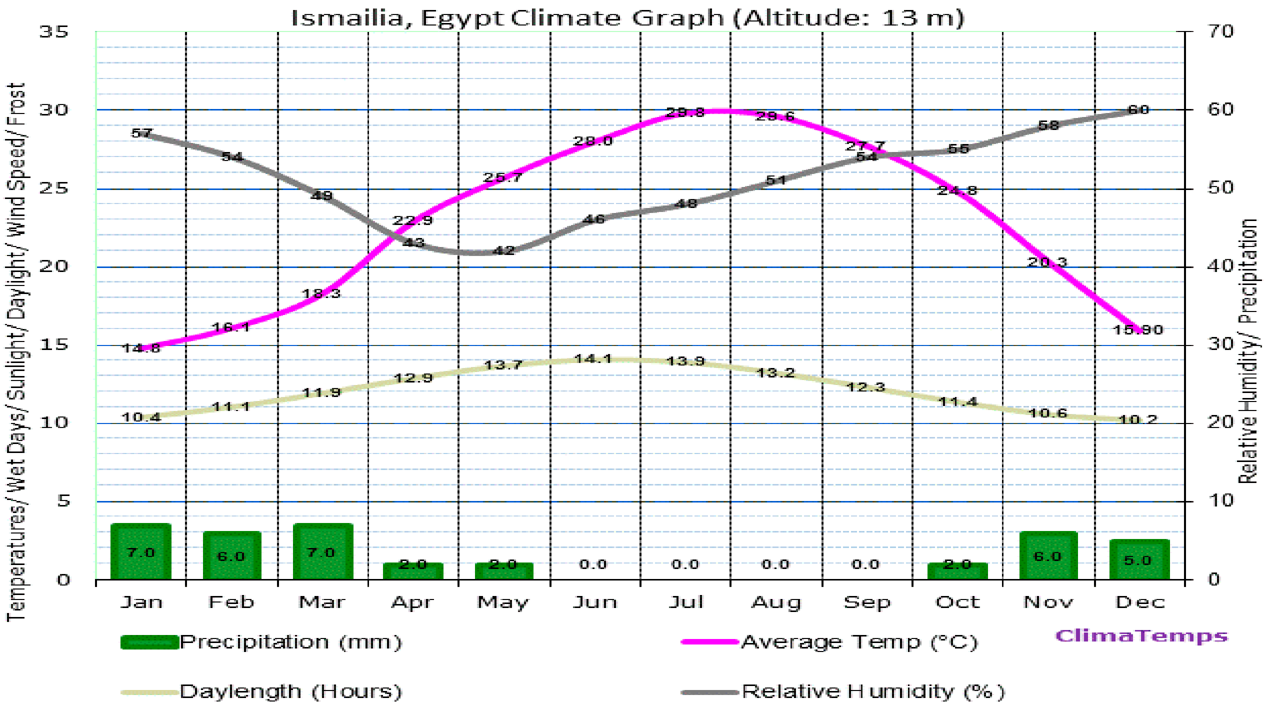

Figure 1. The climate graph of Ismailia Governorate, Egypt (http://www.cairo.climatemps.com, accessed on 1 December 2021).

2.2. Plant Material and Experimental Design

We used forty eight trees of the 'Valencia' orange cultivar, and four levels of pruning as depicted in Figure 2. Each treatment had four replicates, and each replicate contained three trees. Each treatment contained twelve experimental Valencia orange trees. The following treatments were performed on 15 February for each season:

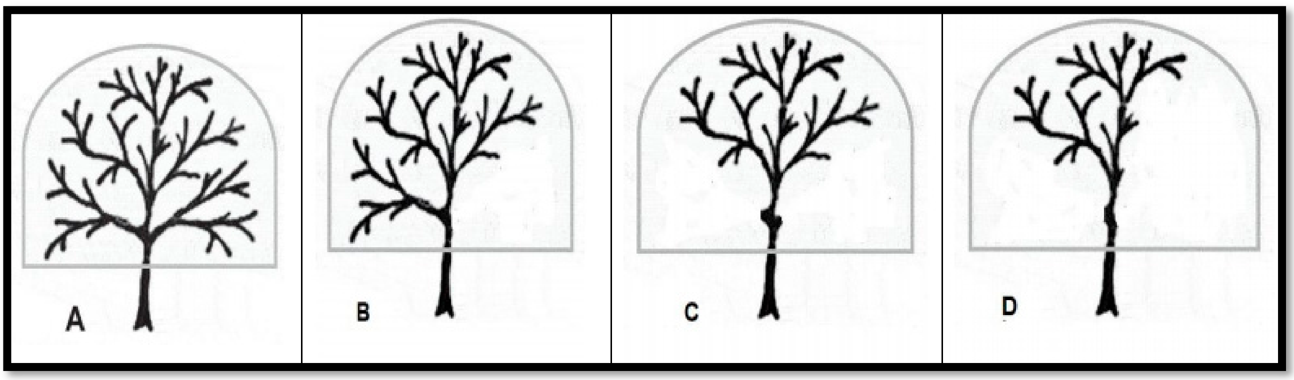

Figure 2. Tree forms used for pruning severity treatments. (**A**) Control; (**B**) light; (**C**) moderate and (**D**) heavy. The diagram sample of the tree (**A**) according to Cronje et al. [15].

T1: Control (un-pruned);
T2: Light pruning: 25% of the major branches (9–12 cm in diameter) were cut off;
T3: Moderate pruning: main branches (9–12 cm in diameter) were cut, 50% of the total;
T4: Heavy pruning: main branches with a diameter of 9 to 12 cm were cut in 75% of cases.

2.3. Measurement of Growth Parameters and Yield

On 15 February, pruning treatments in this study were conducted on two different groups of Valencia orange trees in each season of 2019/2020 and 2020/2021. We recorded the parameters of pruning treatments for the two seasons from these different groups of trees as follows: vegetative growth expressed as average shoot length (cm). To measure shoot length (cm) at the end of the spring cycle, we devoted twenty shoots per tree (five shoots from the four original directions of the orange tree). For leaf area (cm^2), we collected a sample of 20 mature leaves at the end of the growth season (the fifth distal leaf on the shoot) from five leaves from the four origin directions of the orange tree. We also recorded the length and width measurements, and then calculated the leaf area (cm^2) using the following equation [15]: leaf area (cm^2) = 0.49 (length × width) + 19.09. To estimate the volume of the tree canopy (m^3), we measured the height and diameter of the Valencia orange tree using a steel measuring tape for each experimental tree. The tree size, expressed as canopy volume, was measured and calculated using the equation by Zekri [25] as follows: tree canopy volume (m^3) = 0.52 × tree height × (diameter^2). For yield (kg/tree), when TSS/acid was recorded at least 8:1 according to Farag et al. [26], we harvested the oranges during the typical commercial harvesting time under Ismailia Governorate conditions (on 5 February). Yield was specified in kilograms per tree. Moreover, to calculate the increase or decrease in tree yield (kg/tree) compared to the unpruned trees when severe pruning impact was compared to the control, the percentage increase in yield (%) was calculated using the equation from [27] as follows.

$$\text{Increase in yield } (\%) = \frac{\text{Yield (treatment)} - \text{yield (control)}}{\text{yield (control)}} \times 100$$

2.4. Physical Properties of Fruit

We conducted an investigation into the physical and chemical characteristics of 'Valencia' orange fruits during harvest. A sample of ten fruits was selected, which was then replicated three times. The measurements taken included fruit weight and volume, fruit height and diameter, as well as fruit firmness (measured in kg/cm^2) using a pressure tester (specifically, the digital force gauge, model FGV-0.5A to FGV-100A, manufactured by Shimpo Instruments). Additionally, the volume of fruit juice (measured in Ml), rind weight (measured in g), rind thickness (measured in cm), and pulp weight were all recorded.

2.5. Chemical Properties of Fruit

The fruit juice was analyzed for its total soluble solids (°Brix), total acidity percentage, and vitamin C content using the following methods: The total soluble solids of the juice were determined using a digital refractometer, measuring the juice's TSS as °Brix. The total acidity was expressed as a percentage of citric acid in milligrams per 100 milliliters of juice. The TSS/acid ratio was calculated by dividing the total soluble solids by the titratable total acids. The vitamin C content, expressed as milligrams per 100 milliliters of juice, was estimated by titrating a juice sample with 2,6 dichlorophenol indophenol dye, following the A.O.A.C. [28] guidelines.

Statistical Analysis

The ANOVA was performed using Stern's one-way ANOVA Co-stat software version 6.4 and a complete randomized block design. The means were then compared using Duncan's [29] multiple range testing with a significance level of 5%.

3. Results and Discussion

3.1. Effect of Pruning Severity on Vegetative Growth

3.1.1. Shoot Length

The length of the shoots in the 'Valencia' orange trees was significantly affected by the extent of renewal pruning (Figure 3A). When the trees were pruned at a severity level of 75%, they had the longest shoots, followed by those pruned at 50 and 25% severity levels, as well as the unpruned trees (control). The shortest shoot length was observed in the unpruned trees. Increasing the pruning rate directly led to longer shoot measurements. This could be attributed to the presence of high levels of stored carbohydrates from the previous growth season, which provided favorable conditions for the vigorous growth of new branches. These findings are consistent with Dashora et al. [18], who found that severe rejuvenation pruning of 'Nagpur' mandarin trees resulted in increased shoot length. The increase in shoot length due to pruning severity may be associated with more resources being directed to a smaller number of branches after pruning, as well as the removal of unhealthy shoots that acted as nutrient sinks rather than sources [30]. The importance of proper nutrition and metabolite balance in this aspect was also observed in mango trees by Pandey [30], who reported the highest shoot length after rejuvenation pruning. Additionally, Awasthi and Mitra 34 discovered that pruned trees had longer shoots compared to unpruned plants.

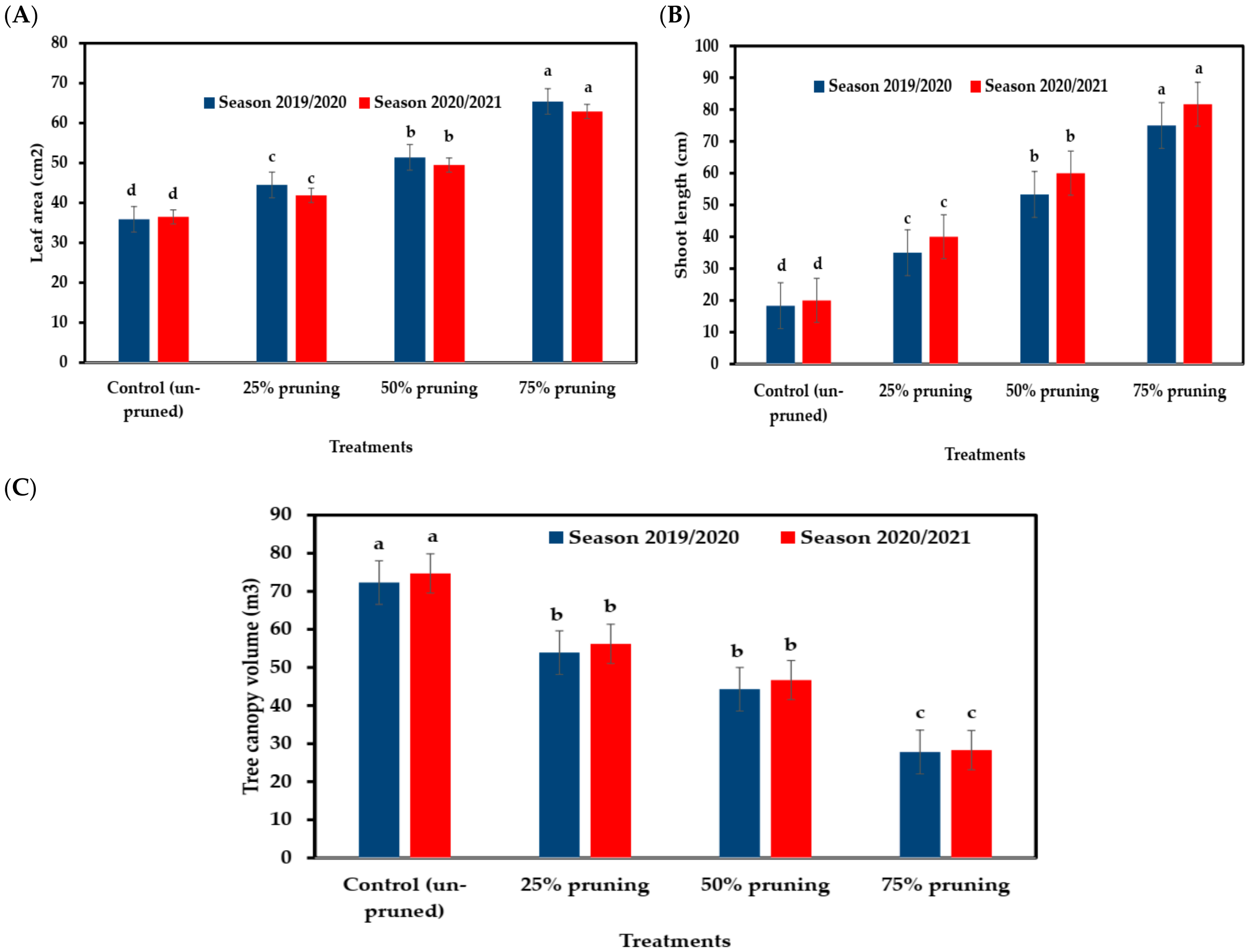

Figure 3. Effect of pruning severity on: (**A**) shoot length (cm), (**B**) leaf area (cm^2) and (**C**) tree canopy volume (m^3) of 'Valencia' orange trees during 2019/2020 and 2020/2021 seasons. The bars represent average values plus or minus the standard error (n = 12). Distinguishing letters above the columns indicate that there are significant differences between the pruning treatments at a significance level of $p < 0.05$ based on Bartlett's test.

3.1.2. Leaf Area

The data shown in Figure 3B demonstrated that all levels of pruning significantly increased the leaf area of the 'Valencia' orange trees compared to the control (unpruned) trees. Trees pruned at 75% severity had the largest leaf area, followed by those pruned at 50 and 25% renewal pruning, and finally the unpruned trees. Increasing the pruning intensity directly resulted in the growth of the vegetative area, particularly the leaf area. Our results indicate a clear pattern where increasing the pruning severity leads to an increase in mature leaf size. The control group had the smallest leaf area. Similar findings were reported by Salama et al. [19] for 'Olinda' orange trees, and by Hassan et al. [31] for acid lime and lemon trees, showing that various pruning treatments can enhance leaf area. The increase in leaf area could be attributed to the availability of more photosynthesis and nutrients in heavily pruned trees, which promote vegetative growth by stimulating cell division and tissue production [14] in lemon trees. Comparatively, guava trees demonstrated improved vegetative growth with increasing pruning severity compared to control plants [32].

3.1.3. Tree Canopy Volume

The results presented in Figure 3C clearly demonstrate the impact of different levels of pruning severity on the canopy volume of the 'Valencia' orange trees during the 2019/2020 and 2020/2021 seasons. The trees that were pruned by removing 75% of the main old branches had the smallest canopy volumes compared to those pruned by removing 50, 25%, and the control treatment. In both seasons, there were no significant differences between the 50 and 25% pruning treatments. This finding is consistent with Chueca et al. [33], who also observed a decrease in canopy size percentage in Navel Foyos orange trees due to pruning. The variation in canopy volume and tree vigor could be attributed to the rejuvenation pruning treatment [34]. Canopy volume improved over the course of the experiment in 'Nadorcott' mandarin trees regardless of the treatment, although there were significant differences between treatments [35]. This aligns with earlier research [34] that suggested unpruned trees have higher tree spread and canopy volume than pruned trees. Our research indicates that increasing pruning severity significantly enhances vegetative growth parameters such as shoot length and leaf area, while reducing canopy size in 'Valencia' orange trees when compared to control trees. We observed a clear trend indicating that higher levels of pruning severity led to improved vegetative growth characteristics. However, this trend did not apply to canopy size, as it decreased as pruning levels increased, reaching its lowest point at a severity of 75%. The relationship between pruning intensity and canopy height had a significant impact on all the evaluated metrics. In conclusion, moderate pruning was found to be the optimal approach for mango trees [36].

3.2. Effect of Pruning Severity on Yield/Tree

The data in Figure 4A clearly demonstrate that pruning the 'Valencia' orange trees on 15 February led to a significant increase in the yield per tree compared to the unpruned control. The highest fruit yield per tree was observed with a severity of 75% pruning, followed by 50 and 25% severity. The unpruned trees had the lowest yield at approximately 64 kg/tree. These findings align with a study by Umar et al. [37], which found that severe pruning of 12-year-old 'Kinnow' mandarin trees improved yield compared to light or no pruning. Similarly, Salem et al. [38] reported that increasing pruning severity resulted in the highest increase in fruit retention percentage for 'Balady' mandarin trees compared to the control. Dashora et al. [18] also discovered a positive correlation between the level of rejuvenation pruning and fruit yield per tree. Hamdy [39] found that both 'Murcott' and 'Fremont' mandarin trees significantly increased their yield per tree with moderate trimming (50%). The increase in yield observed with severe pruning (75%), moderate pruning (50%), and light pruning (25%) compared to the control can be attributed to the positive impact of removing old main branches, allowing light to penetrate the tree and promote the growth of leafless inflorescence. Salama et al. [19] found similar results for 'Olinda' orange trees, where pruning (removing 15, 30, and 45% of the tree canopy) improved fruit yield per tree and reduced fruit drop. The results from this study also indicated a nearly 20% increase in fruit yield per tree compared to unpruned trees in the two seasons analyzed (Figure 2B). This finding aligns with the results reported by Hamdy [39] for 'Murcott' and 'Fremont' mandarin trees. Furthermore, Chueca et al. [33] found that manual pruning led to an increase in yield per tree for 'Navel Foyos' orange trees compared to mechanical pruning. The literature suggests that pruning effects vary between young and mature citrus trees, depending on the type and placement of the branches cut and the changes in light interception before and after pruning. Therefore, variations in pruning form, severity, and tree age may have influenced the differences observed in the study during the trial period. Overall, it can be concluded that pruning resulted in an increased yield per tree compared to the control, with the highest yield obtained from 75% pruning severity, followed by 50 and 25%. This finding highlights that increasing pruning levels in mature Valencia orange trees promotes the exposure of the inner part of the tree to light, activating flowering buds, improving fruit set, and ultimately leading to an increased yield.

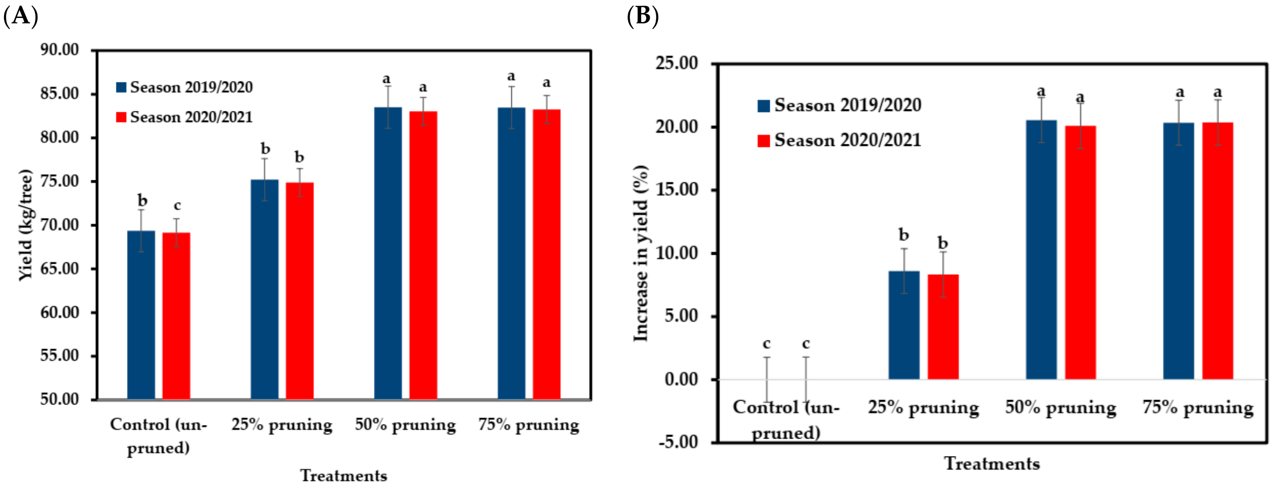

Figure 4. Effect of pruning severity on: (**A**) yield (kg/tree), and (**B**) increasing yield (%) of 'Valencia' orange trees during 2019/2020 and 2020/2021 seasons. The bars represent average values plus or minus the standard error (n = 12). Distinguishing letters above the columns indicate that there are significant differences between the pruning treatments at a significance level of $p < 0.05$ based on Bartlett's test.

3.3. Physical Characteristics of Fruit

3.3.1. Fruit Weight and Volume

The size of the fruit plays a significant role in determining the marketability and profitability of the 'Valencia' orange. Large fruits command higher prices in the export market. The results from Figure 5B–D and Figure 6A clearly demonstrate that pruning the 'Valencia' orange trees on 15 February with pruning levels of 25, 50, or 75% resulted in increased fruit weight, volume, diameter, and height compared to the control group in both seasons studied. The effect was more pronounced with a higher pruning level of 75% compared to 25 and 50%. Similar patterns were observed in other fruit parameters such as fruit pulp weight, rind thickness, and rind weight (Figure 6A–D). The trees in the control group, which had a higher number of fruits per tree, produced the smallest orange fruit dimensions in the two study seasons (Figure 5A). The negative correlation between fruit volume and yield was found to be statistically significant. Additionally, a strong relationship between fruit volume and tree canopy volume further highlighted the impact of pruning on production and fruit volume. These findings align with previous research conducted by Salama et al. [19], who reported that pruning (removing 15, 30, and 45% of the tree canopy) improved the fruit size of 'Olinda' orange trees. Cronje et al. [40] also observed an improvement in fruit volume of 'Nadorcott' mandarin through pruning. The increase in fruit dimensions (weight and volume) can be attributed to the increase in photosynthesis produced by a larger number and area of leaves, resulting in a significant boost in fruit weight and size. The findings of this study support Hamdy's discovery [39] that pruning enhanced fruit weight, diameter, and length in 'Murcott' and 'Fremont' mandarin trees.

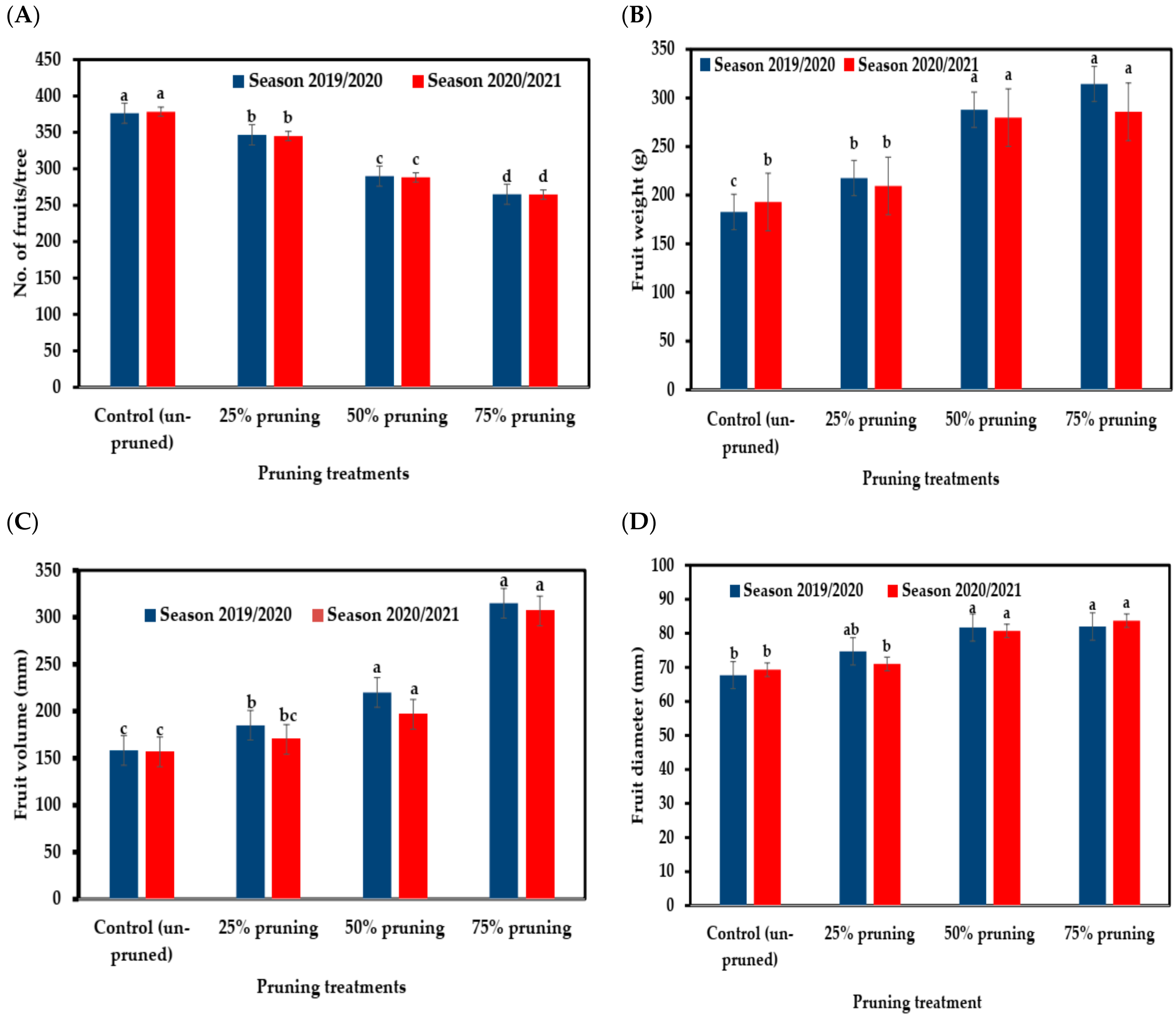

Figure 5. Effect of pruning severity on: (**A**) number of fruits/tree, (**B**) fruit weight (g), (**C**) fruit volume and (**D**) fruit diameter (mm) of 'Valencia' orange trees during 2019/2020 and 2020/2021 seasons. T1: control, T2: light pruning, T3: moderate pruning and T4: heavy pruning. The bars represent average values plus or minus the standard error (n = 12). Distinguishing letters above the columns indicate that there are significant differences between the pruning treatments at a significance level of $p < 0.05$ based on Bartlett's test.

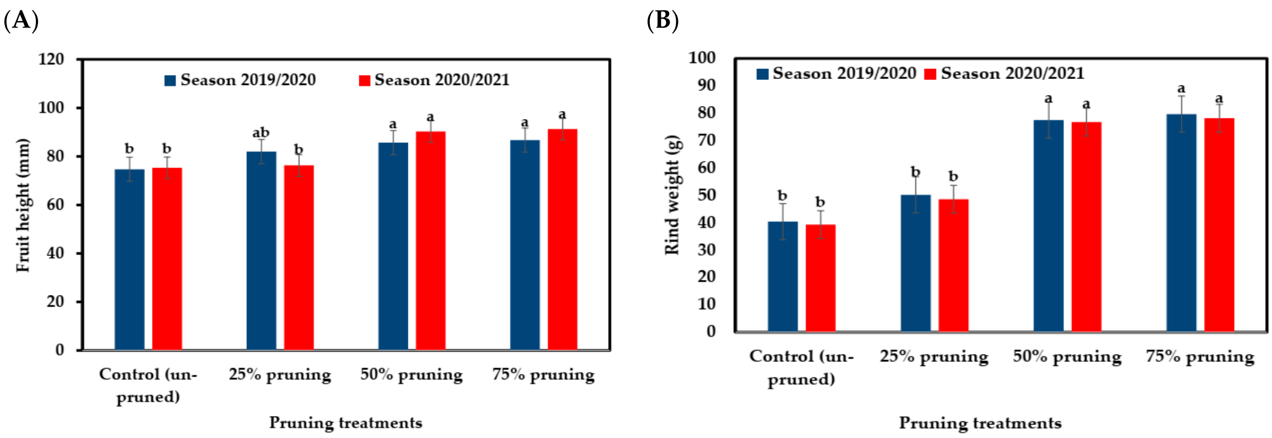

Figure 6. *Cont.*

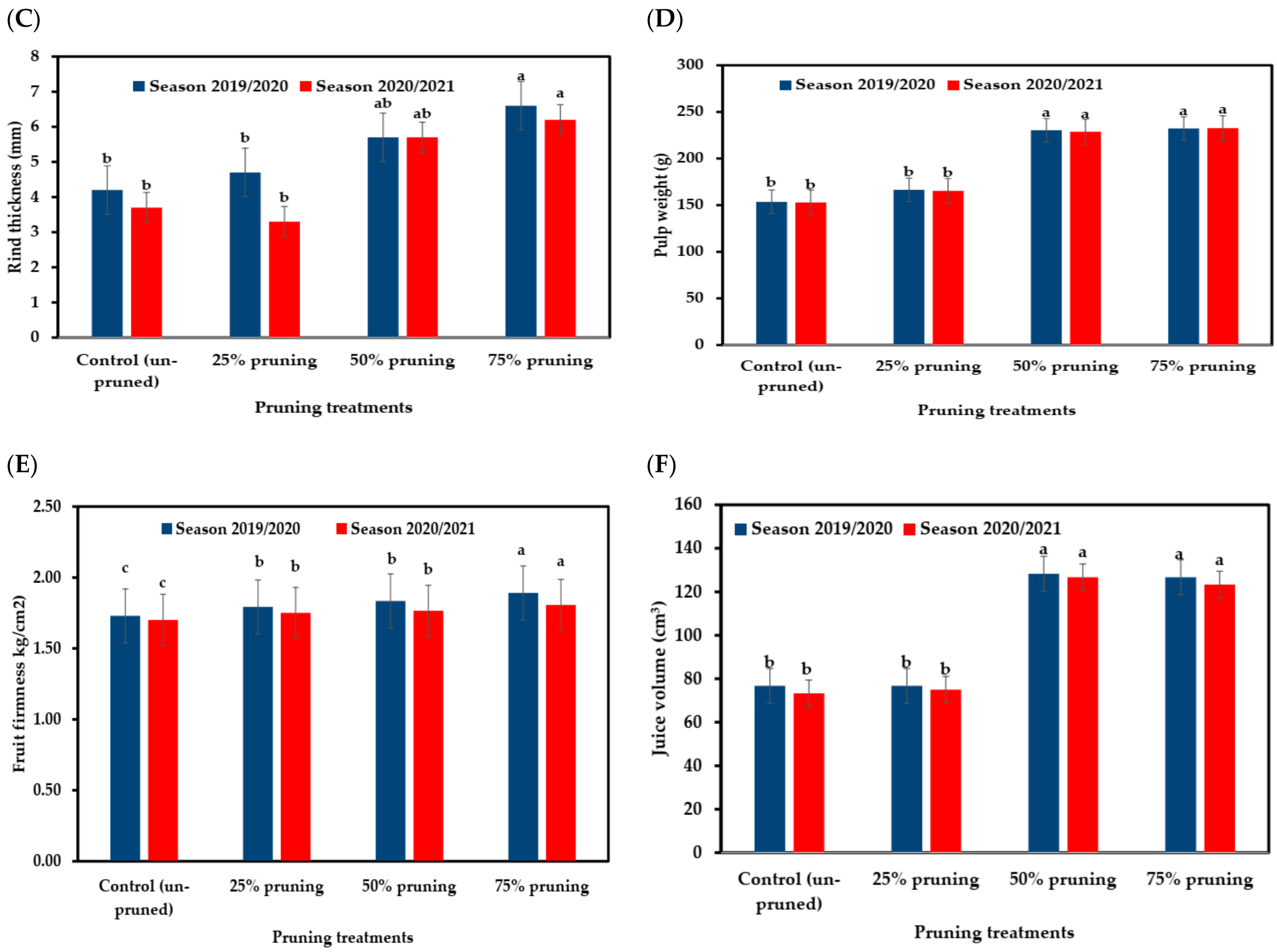

Figure 6. Effect of pruning severity on: (**A**) fruit height (mm), (**B**) rind weight (g), (**C**) rind thickness (mm), (**D**) pulp weight (g), (**E**) fruit firmness (kg/cm^2) and (**F**) juice volume (cm^3) of 'Valencia' orange trees during 2019/2020 and 2020/2021 seasons. T1: control, T2: light pruning, T3: moderate pruning and T4: heavy pruning. The bars represent average values plus or minus the standard error (n = 12). Distinguishing letters above the columns indicate that there are significant differences between the pruning treatments at a significance level of $p < 0.05$ based on Bartlett's test.

3.3.2. Fruit Firmness

The results shown in Figure 6E indicate that pruning treatments had a significant impact on improving the firmness of fruit (kg/cm^2) in the 'Valencia' orange tree compared to the unpruned tree. Of the pruning levels, those trees pruned at 75% showed the highest fruit firmness, followed by other pruning treatments or the control group. Although there were no significant differences between 50 and 25% pruning severity in the two seasons of the study, the effects of pruning on fruit quality and yield varied for the researchers. For instance, previous research [39] also found that pruning increased the firmness of 'Murcott' mandarin fruit, which aligns with our findings in the 'Valencia' orange.

3.3.3. Juice Content of Fruit

The application of pruning greatly affected the volume of juice in the fruit, as shown in Figure 6F. Comparing the unpruned control group, which had the lowest juice volume, the fruit from trees pruned at 75 percent pruning level had the highest juice volume. These findings support the previous research by Yildirim et al. [41] who found that pruning had a significant positive impact on the juice content of Star Ruby grapefruit. Pruning the 'Fermont' and 'Murcott' mandarin cultivars also significantly increased the fruit juice content, as stated by Hamdy [39]. The type of pruning affected the juice content of the fruit [42]. The greater juice content in the fruits from plants that underwent pruning may be attributed to improved sunlight penetration and nutrient availability for the trees [43]. In conclusion, increasing the pruning levels in old Valencia orange trees reduced the number of fruits on the tree. However, the results also confirmed the enhancement of important physical characteristics of the fruits, such as fruit weight, size, juice content, and overall dimensions, which are crucial aspects of fruit quality.

3.4. Chemical Characteristics of Fruit

3.4.1. TSS (°Brix), TSS/Acid Ratio and Total Acidity

The results illustrated in Figure 7A–C demonstrated a significant increase in the TSS (°Brix) and TSS/acid ratio of 'Valencia' fruit juice following pruning treatments were done on 15 February. Specifically, the moderate pruning treatment of 50% resulted in the highest TSS (°Brix) and TSS/acid ratio compared to other treatments and the control group (unpruned). However, there was no notable difference observed between the 75% severity pruning and the control treatments. These findings align with previous studies by [44,45], which also reported that all pruning methods eventually enhanced the ratio of soluble solids to acidity compared to the unpruned control group. Furthermore, Umar et al. [37] discovered that pruning treatments significantly increased the TSS percentage and ripening index (TSS: acid ratio) in fruits of 'Kinnow' mandarin trees. The higher TSS content in fruits can be attributed to an increased buildup of carbohydrates and sufficient supply 47, 50, 51. The data additionally indicated that 75% heavy pruning and the control trees produced acidic fruits with the highest total acidity values, followed by 25% light pruning or 50% moderate pruning. These results are consistent with the findings of Javaid et al. [46], who observed a decrease in overall acidity of the Kinnow mandarin variety as a result of trimming, and Martin-Gorriz et al. [47] on 'Fortune' mandarin. Furthermore, Hamdy 41 studied 'Fermont' and 'Murcott' mandarin trees.

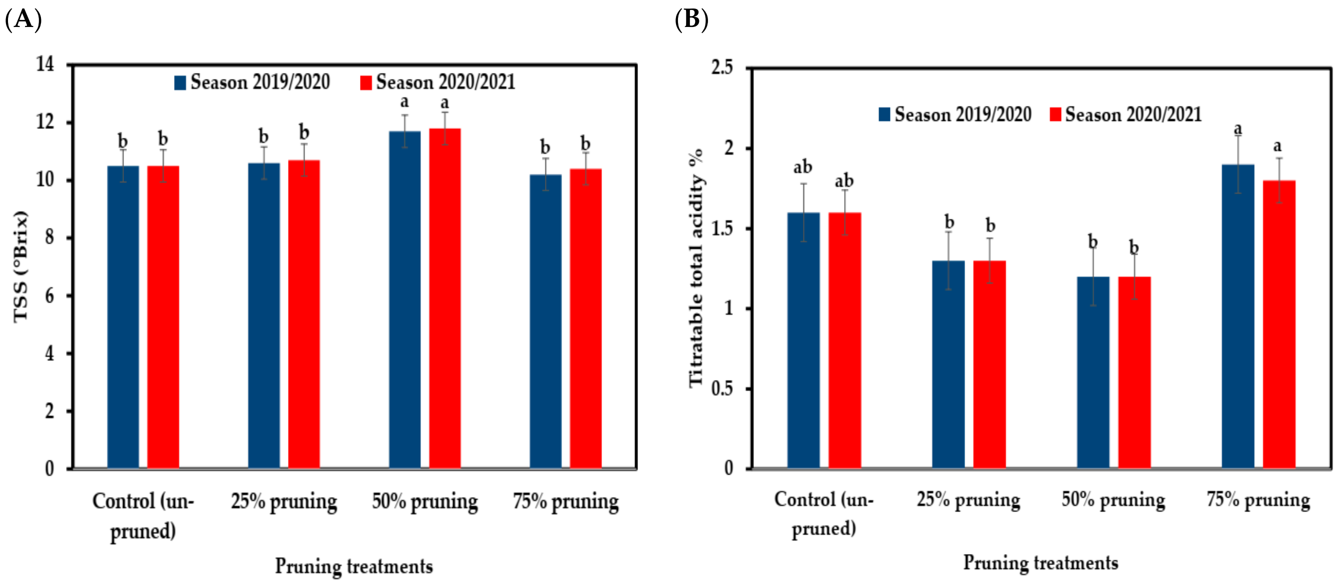

Figure 7. *Cont.*

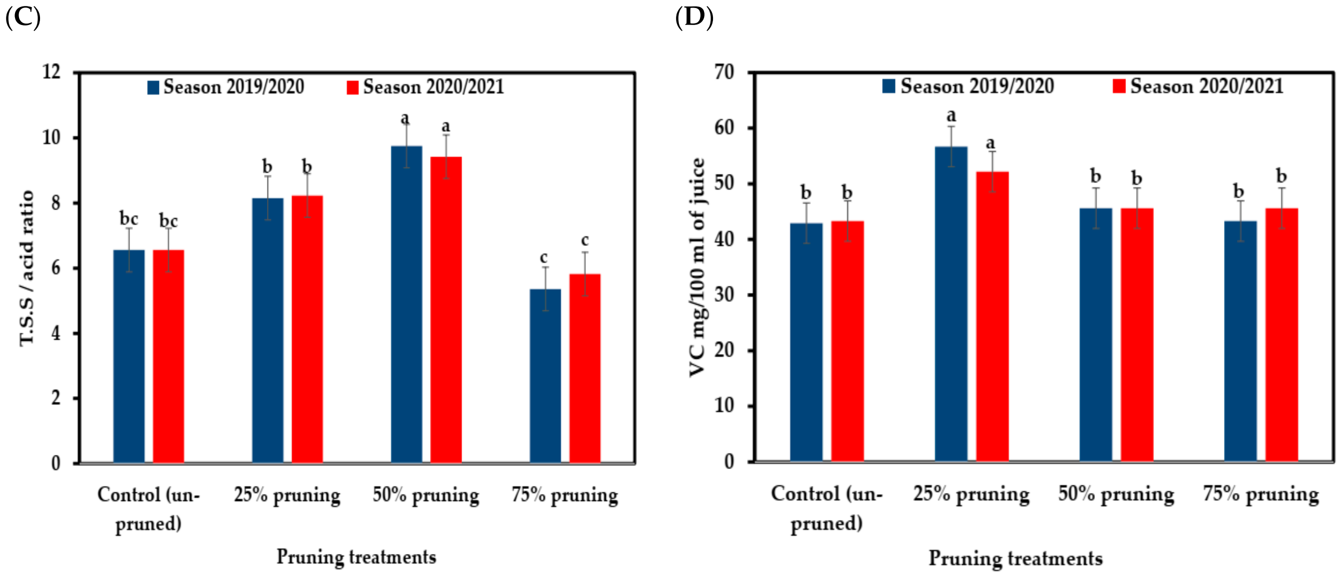

Figure 7. Effect of pruning severity on: (**A**) TSS (°Brix), (**B**) titratable total acidity (%) (**C**) TSS/acid ratio, (**D**) vitamin C of 'Valencia' orange trees during 2019/2020 and 2020/2021 seasons. T1: control, T2: light pruning, T3: moderate pruning and T4: heavy pruning. The bars represent average values plus or minus the standard error (n = 12). Distinguishing letters above the columns indicate that there are significant differences between the pruning treatments at a significance level of $p < 0.05$ based on Bartlett's test.

3.4.2. Vitamin C

The results displayed in Figure 7D demonstrated that the light pruning treatments had a significant impact on the concentration of Vitamin C when compared to the control group. These findings support the earlier study by Salama et al. [19], which found that trimming "Olinda" orange trees increased the concentration of ascorbic acid in the fruit. Similarly, Baghdady [48] discovered that excessive pruning (eliminating 75 percent of 2-year-old branches) resulted in the highest level of vitamin C in "Balady" mandarin, compared to moderate pruning and control trees. The increase in ascorbic acid content in the fruits could be attributed to the increased availability of nutrients such as potassium. Rekha [49] found that potassium may have played a role in reducing the rate of the enzyme system responsible for ascorbic acid oxidation, which allowed the plants to accumulate more ascorbic acid in the fruits.

4. Conclusions

To sum up, the pruning level technique is a successful method, particularly for older evergreen trees. Selective pruning is rarely carried out on citrus trees since they are evergreen. 'Valencia' orange trees demonstrated increased vegetative growth, including shoot growth, leaf area, and canopy volume, when subjected to severe pruning. The most effective pruning levels for canopy volume were determined to be 25 or 50%. Additionally, pruning resulted in higher fruit yield per tree and greater yield percentage compared to unpruned trees. The maximum fruit yield per tree increased by 50 or 75%, based on the severity of pruning. Furthermore, pruning treatments led to enhancements in the physical characteristics of the fruit, such as weight, volume, and juice content. The chemical properties, including total soluble solids in the fruit juice, also improved. In conclusion, applying different levels of pruning severity in February can effectively enhance vegetative growth and the physical and chemical properties of old Valencia orange trees. Moreover, it can increase fruit yield by almost 20% compared to the control.

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References

1. Zhong, G.; Nicolosi, E. Citrus Origin, Diffusion, and Economic Importance. In *The Citrus Genome*; Gentile, A., La Malfa, S., Deng, Z., Eds.; Compendium of Plant Genomes; Springer International Publishing: Cham, Switzerland, 2020; pp. 5–21. ISBN 978-3-030-10799-4.
2. Liu, Y.; Heying, E.; Tanumihardjo, S.A. History, Global Distribution, and Nutritional Importance of Citrus Fruits. *Compr. Rev. Food Sci. Food Saf.* **2012**, *11*, 530–545. [CrossRef]
3. Barry, G.H.; Caruso, M.; Gmitter, F.G. Commercial Scion Varieties. In *The Genus Citrus*; Elsevier: Amsterdam, The Netherlands, 2020; pp. 83–104. ISBN 978-0-12-812163-4.
4. Ramana, K.V.R.; Govindarajan, V.S.; Ranganna, S.; Kefford, J.F. Citrus Fruits—Varieties, Chemistry, Technology, and Quality Evaluation. Part I: Varieties, Production, Handling, and Storage. *CRC Crit. Rev. Food Sci. Nutr.* **1981**, *15*, 353–431. [CrossRef]
5. FAOSTAT. *Food and Agriculture Organization Corporate Statistical Database (2020)*; Food and Agriculture Organization of the United Nations, Crops: Rome, Italy, 2020.
6. El-Gioushy, S.F.; Sami, R.; Al-Mushhin, A.A.M.; Abou El-Ghit, H.M.; Gawish, M.S.; Ismail, K.A.; Zewail, R.M.Y. Foliar Application of ZnSO4 and CuSO4 Affects the Growth, Productivity, and Fruit Quality of Washington Navel Orange Trees (*Citrus sinensis* L.) Osbeck. *Horticulturae* **2021**, *7*, 233. [CrossRef]
7. Robles, J.M.; Botía, P.; Pérez-Pérez, J.G. Sour Orange Rootstock Increases Water Productivity in Deficit Irrigated 'Verna' Lemon Trees Compared with Citrus Macrophylla. *Agric. Water Manag.* **2017**, *186*, 98–107. [CrossRef]
8. Marsal, J.; Johnson, S.; Casadesus, J.; Lopez, G.; Girona, J.; Stöckle, C. Fraction of Canopy Intercepted Radiation Relates Differently with Crop Coefficient Depending on the Season and the Fruit Tree Species. *Agric. For. Meteorol.* **2014**, *184*, 1–11. [CrossRef]
9. Krajewski, A.J.; Krajewski, S.A. Canopy management of sweet orange, grapefruit, lemon, lime and mandarin trees in the tropics: Principles, practices and commercial experiences. *Acta Hortic.* **2011**, *894*, 65–76. [CrossRef]
10. Dhaliwal, H.S.; Banke, A.K.; Kumar, L.; Brar, J.S. Standardization of Pruning Severity for Healthy Bud Production in 'Kinnow' (*C. nobilis* × *C. deliciosa*) Mother Plants. *Acta Hortic.* **2016**, *1130*, 311–317. [CrossRef]
11. Lal, S.; Kumar, D.; Singh, D.B.; Ahmed, N.; Kumar, R.; Dar, G.A. Effect of Pre-Harvest Application of Calcium Chloride and Gibberellic Acid on Shelf-Life and Post-Harvest Quality of Apricot (*Prunus armeniaca* L.) Cv. Harcot. *J. Hortic. Sci.* **2011**, *6*, 46–51. [CrossRef]
12. Browner, C.H. Plants Used for Reproductive Health in Oaxaca, Mexico. *Econ. Bot.* **1985**, *39*, 482–504. [CrossRef]
13. Suklabaidya, D.A.; Mehta, K. Rejuvenation of Senile Horticultural Plantations for Improved Productivity and Quality. *Int. J. Hortic. Agric. Food Sci.* **2019**, *3*, 173–181. [CrossRef]
14. Rani, A.; Misra, K.; Rai, R.; Singh, O. Effect of Shoot Pruning and Paclobutrazol on Vegetative Growth, Flowering and Yield of Lemon (*Citrus limon* Burm.) Cv. Pant Lemon-1. *J. Pharmacogn. Phytochem.* **2018**, *7*, 2588–2592.
15. Cronje, R.; Human, C.; Ratlapane, I. Pruning Strategies for Young 'Nadorcott' Mandarin Trees Planted in High Density Orchards in South Africa. *Int. J. Fruit Sci.* **2021**, *21*, 921–931. [CrossRef]
16. He, L.; Schupp, J. Sensing and Automation in Pruning of Apple Trees: A Review. *Agronomy* **2018**, *8*, 211. [CrossRef]
17. Intrigliolo, F.; Roccuzzo, G. Modern Trends of Citrus Pruning in Italy. *Adv. Hortic. Sci.* **2013**, *25*, 187–192. [CrossRef]
18. Singh, J.; Dashora, L.K.; Bhatnagar, P.; Singh, B. Impact of pruning on rejuvenation of declining Nagpur mandarin (*Citrus reticulata* Blanco.) orchard. *Indian J. Agrofor.* **2016**, *18*, 53–57.

19. Salama, B.; Abou-Hadid, A.; Abdelhamid, N.; El-Shinawy, M. Effect of prunning pattern and soil mulching on yield and quality of keitt mango in new reclaimed lands. *Arab Univ. J. Agric. Sci.* **2018**, *26*, 147–159. [CrossRef]
20. Vashisth, A.; Nagarajan, S. Exposure of Seeds to Static Magnetic Field Enhances Germination and Early Growth Characteristics in Chickpea (*Cicer arietinum* L.). *Bioelectromagnetics* **2008**, *29*, 571–578. [CrossRef]
21. Tang, Y.; Hou, C.J.; Luo, S.M.; Lin, J.T.; Yang, Z.; Huang, W.F. Effects of Operation Height and Tree Shape on Droplet Deposition in Citrus Trees Using an Unmanned Aerial Vehicle. *Comput. Electron. Agric.* **2018**, *148*, 1–7. [CrossRef]
22. Gongal, A.; Amatya, S.; Karkee, M.; Zhang, Q.; Lewis, K. Sensors and Systems for Fruit Detection and Localization: A Review. *Comput. Electron. Agric.* **2015**, *116*, 8–19. [CrossRef]
23. Ladaniya, M.S.; Marathe, R.A.; Das, A.K.; Rao, C.N.; Huchche, A.D.; Shirgure, P.S.; Murkute, A.A. High Density Planting Studies in Acid Lime (*Citrus aurantifolia* Swingle). *Sci. Hortic.* **2020**, *261*, 108935. [CrossRef]
24. Zekri, M. Factors Affecting Citrus Production and Quality. *Citrus Industry*, December 2011. pp. 1–4.
25. Ahmed, F.F. and Morsy, M.H. A New Method for Measuring Leaf Area in Different Fruit Species. *Minia J. Agric. Res. Dev.* **1999**, *19*, 97–105.
26. Zekri, M. 594 Citrus Rootstocks Affect Scion Nutrition, Fruit Quality, Growth, Yield, and Economical Return. *HortScience* **2000**, *35*, 499C–499. [CrossRef]
27. Farag, A.R.A. Effect of Bud Load and Fruiting Unit Length of the Autumn Crisp Grape Variety on Growth, Yield, and Fruit Quality. *Alex. J. Agric. Sci.* **2022**, *67*, 182–192. [CrossRef]
28. Mohamed Abd El-Naby, S.K.; Ahmed Mohamed, A.A.; Mohamed El-Naggar, Y.I. Effect of melatonin, ga3 and naa on vegetative growth, yield and quality of 'canino' apricot fruits. *Acta Sci. Pol. Hortorum Cultus* **2019**, *18*, 3. [CrossRef]
29. AOAC Association of Official Analytical Chemist. *Official Methods of Analysis*, 18th ed.; AOAC: Washington, DC, USA, 2016; Volume 18.
30. Duncan, D.B. Multiple Range and Multiple F Tests. *Biometrics* **1955**, *11*, 1. [CrossRef]
31. Pandey, S.N. *Mango Cultivars. Mango Cultivation*; International Book Distributing Company: Lucknow, India, 1998.
32. Hasan, M.; Rahim, M.A.; Islam, A.K.M.S. Islam Effect of Management Practices on the Growth and Yield of Lime and Lemon. *Int. J. Biosci. IJB* **2016**, *8*, 22–33. [CrossRef]
33. Adhikari, S.; Kandel, T.P. Effect of Time and Level of Pruning on Vegetative Growth, Flowering, Yield, and Quality of Guava. *Int. J. Fruit Sci.* **2015**, *15*, 290–301. [CrossRef]
34. Chueca, P.; Mateu, G.; Garcerá, C.; Fonte, A.; Ortiz, C.; Torregrosa, A. Yield and Economic Results of Different Mechanical Pruning Strategies on "Navel Foyos" Oranges in the Mediterranean Area. *Agriculture* **2021**, *11*, 82. [CrossRef]
35. Sharma, R.R.; Singh, R. Pruning Intensity Modifies Canopy Microclimate, and Influences Sex Ratio, Malformation Incidence and Development of Fruited Panicles in 'Amrapali' Mango (*Mangifera indica* L.). *Sci. Hortic.* **2006**, *109*, 118–122. [CrossRef]
36. Stander, O.P.J.; Barry, G.H.; Cronjé, P.J.R. Fruit Load Limits Root Growth, Summer Vegetative Shoot Development, and Flowering in Alternate-Bearing 'Nadorcott' Mandarin Trees. *J. Am. Soc. Hortic. Sci.* **2018**, *143*, 213–225. [CrossRef]
37. Sanjay, K.S.; Sanjay, K.S.; Ram, R.S. Effects of Pruning Intensity on the Biochemical Status of Shoot Buds in Three Mango (*Mangifera indica* L.) Cultivars Planted at High Density. *J. Hortic. Sci. Biotechnol.* **2010**, *85*, 483–490. [CrossRef]
38. Umar, M.; Ahmad, S.; Haider, S.T.-A.; Naz, S. Effect of Pruning to Improve Yield and Fruit Quality of 'Kinnow' Mandarin Plants under High Density Plantation. *J. Hortic. Sci. Technol.* **2019**, *2*, 85–89. [CrossRef]
39. Salem, A.T.; Hasseb, G.M.; Mostafa, H. *Effect of Pruning Severity on Vegetative Growth, Flowering and Fruit Setting of Balady Mandarin Trees (Citrus Reticulata Blanco)*; Cairo University: Cairo, Egypt, 2009.
40. Hamdy, A.E. Effect of Pruning Severity on Yield and Fruit Quality of Two Mandarin Cultivars. *Acta Hortic.* **2018**, *2016*, 135–144. [CrossRef]
41. Yıldırım, B.; Yeşiloğlu, T.; İncesu, M.; Kamiloğlu, M.; Çimen, B.; Tamer, Ş. Effects of 2,4-DP (2,4-Dichlorophenoxypropionic Acid) Plant Growth Regulator on Fruit Size and Yield of Valencia Oranges (*Citrus sinensis* Osb.). *N. Z. J. Crop Hortic. Sci.* **2012**, *40*, 55–64. [CrossRef]
42. Morales, P.; Davies, F.S.; Littell, R.C. Pruning and Skirting Affect Canopy Microclimate, Yields, and Fruit Quality of 'Orlando' Tangelo. *HortScience* **2000**, *35*, 30–35. [CrossRef]
43. Nasir, M.; Khan, A.S.; Basra, S.M.A.; Malik, A.U. Foliar Application of Moringa Leaf Extract, Potassium and Zinc Influence Yield and Fruit Quality of 'Kinnow' Mandarin. *Sci. Hortic.* **2016**, *210*, 227–235. [CrossRef]
44. Joubert, F.J.; Plessis, M.H.D.; Stassen, P.J.C. Pruning Strategies to Alleviate Overcrowding in Higher Density Citrus Orchards. *J. Appl. Hortic.* **2000**, *02*, 1–5. [CrossRef]
45. Aparicio-Durán, L.; Gmitter, F.G., Jr.; Arjona-López, J.M.; Calero-Velázquez, R.; Hervalejo, Á.; Arenas-Arenas, F.J. Water-Stress Influences on Three New Promising HLB-Tolerant Citrus Rootstocks. *Horticulturae* **2021**, *7*, 336. [CrossRef]
46. Saleem, H.; Zaidi, S.J. Recent Developments in the Application of Nanomaterials in Agroecosystems. *Nanomaterials* **2020**, *10*, 2411. [CrossRef]
47. Martin-Gorriz, B.; Porras Castillo, I.; Torregrosa, A. Effect of Mechanical Pruning on the Yield and Quality of 'Fortune' Mandarins. *Span. J. Agric. Res.* **2014**, *12*, 952. [CrossRef]

48. Baghdady, G.A. Effect of Pruning on Yield and Fruit Quality of Balady Mandarin. *Ann. Agric. Sc. Moshtohor.* **1993**, *13*, 1158–1166.
49. Rekha, C.; Poornima, G.; Manasa, M.; Abhipsa, V.; Devi, J.P.; Kumar, H.T.V.; Kekuda, T.R.P. Ascorbic Acid, Total Phenol Content and Antioxidant Activity of Fresh Juices of Four Ripe and Unripe Citrus Fruits. *Chem. Sci. Trans.* **2012**, *1*, 303–310. [CrossRef]