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Development of Israeli mango cultivars in the Brazilian semiarid region

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Abstract – The objective of this work was to evaluate the initial adaptive performance of Israeli mango tree cultivars grown in the submedian region of the São Francisco Valley, Brazil. The experiment was carried out from January 2019 to July 2020 using seedlings of the Omer and Shelly cultivars, at six months after transplanting, at a 3×6 m spacing. The experimental design was randomized complete blocks in a 2×3 factorial arrangement, corresponding to the two Israeli mango tree cultivars and the number of branches after formative pruning (three, four, and five branches), with four replicates. Biometric, biochemical, and photosynthetic variables were analyzed, differing between the evaluation times after pruning. The Omer cultivar is more vigorous than Shelly, and formative pruning with three, four, and five branches is recommended for both mango cultivars under the cultivation conditions of the São Francisco Valley.

Index terms: *Mangifera indica*, formative pruning, gas exchange, 'Omer', 'Shelly'.

Desenvolvimento de cultivares de mangueiras israelenses no semiárido brasileiro

Resumo – O objetivo deste trabalho foi avaliar o desempenho adaptativo inicial de cultivares de mangueiras israelenses cultivadas na região do Submédio do Vale do São Francisco, Brasil. O experimento foi realizado de janeiro de 2019 a julho de 2020, tendo-se utilizado mudas das cultivares Omer e Shelly, aos seis meses após o transplante, em espaçamento de 3×6 m. O delineamento experimental foi em blocos ao acaso, em arranjo fatorial 2×3, correspondente às duas cultivares de mangueiras israelenses e ao número de ramos após a poda de formação (três, quatro e cinco ramos), com quatro repetições. Foram analisadas variáveis biométricas, bioquímicas e fotossintéticas, que diferiram entre as épocas de avaliação após as podas. A cultivar Omer é mais vigorosa que a Shelly, e a poda formativa com três, quatro e cinco ramos é recomendada para ambas as cultivares de manga nas condições de cultivo do Vale do São Francisco.

Termos para indexação: *Mangifera indica*, poda de formação, trocas gasosas, 'Omer', 'Shelly'.

Introduction

Mango (*Mangifera indica* L.) is a fruit tree adapted to tropical and subtropical climates that develops well under conditions with high solar radiation incidence and temperatures (Fitchett et al., 2016), low water availability, and high evaporative demand (Khanum et al., 2020).

However, the expected increases in temperature cause several abiotic stresses, reducing photosynthesis due to a rapid stomatal closure when the energy demand (carbohydrates) of the plant increases (Mudo et al., 2020), decreasing photochemical efficiency (Yanhui et al., 2020), and degrading chloroplasts by the excessive production of reactive oxygen species (Qiu et al., 2019; Zhang et al., 2022). The harmful effects of these stresses vary depending on the plant species, adaptation level, exposure time, and phenological stage (Hassan et al., 2022).

For the adaptation of mango to the environmental conditions of Brazilian semiarid regions, intensive management practices, such as pruning, fertilization, irrigation, and floral induction, are necessary for the expression of the crop's production potential (Santos et al., 2013; Cavalcante et al., 2018; Oldoni et al., 2018). This is especially important for the São Francisco Valley region, located in the semiarid Brazilian Northeast, which represents 69% of national production and 90% of mango exports (Anuário..., 2022).

The main mango cultivars produced in the São Francisco Valley are Tommy Atkins, Keitt, Kent, Haden, and Palmer from the United States (Mouco & Lima Neto, 2018; Anuário..., 2022). Although these cultivars are known in the international market and well exported, Brazilian producers are expanding their niche markets to other distribution centers, which require fruits with different characteristics from those traditionally offered (Mouco & Lima Neto, 2018).

Among the new mango cultivars that have shown good acceptance in the consumer market, the Shelly and Omer Israeli cultivars stand out (Lima Neto, 2020), being recently introduced in the São Francisco Valley, but still with no management recommendations. Cultivar Shelly, a result of the cross between Tommy Atkins and Kent (Cohen et al., 2016), has round fruit, with a weight ranging from 350 to 700 g, a juicy and firm pulp without fibers, and an orange color with a red blush (Lavi et al., 1996). Produced from open pollination, cultivar Omer is a hybrid of the Zillate cultivar and is characterized by an oval shape and average weight of 450 g, with a purple and bright-red skin color, little fiber, a light aroma, and a sweet flavor (Cohen et al., 2016).

The objective of this work was to evaluate the initial adaptive performance of Israeli mango tree cultivars grown in the submedian region of the São Francisco Valley, Brazil.

Materials and Methods

The experiment was conducted during the vegetative stage of seedlings of the Omer and Shelly cultivars, six months after transplanting, from January 2019 to July 2020, in a commercial orchard of Fazenda Le Bourdet, located in the Maniçoba irrigation perimeter, in the municipality of Juazeiro, in the state of Bahia, Brazil (9º20'05.6"S, 40º14'41.1"W). According to Köppen's classification, the climate is BshW, tropical semiarid, hot, with a rainy season in summer and a high evaporation, mean annual temperature of 26ºC, and mean rainfall of 481.7 mm. The soil is classified as a Ferralsol according to World Reference Base for Soil Resources (IUSS Working Group WRB, 2015).

The Omer and Shelly Israeli mango cultivars were provided by Israel's Agricultural Research Organization of Volcani Institute. Seedlings of both cultivars were transplanted on 6/22/2018, four months after grafted when reaching a height of 60 cm, spaced at 3×6 m. Each plant was irrigated by a surface emitter (micro-sprinkler) at an individual flow of 2.33 L h^{-1}, following the water requirements of the crop (Lipan et al., 2021).

Sixty days before the seedlings were transplanted, the soil was prepared using two plowing and harrowing operations. The preparation of the pits and the application of fertilizers for the initial stage of the crop were carried out according to the methodologies of Silva (2009) and to the demands of the crop considering the regional cultivation conditions (Cavalcante et al., 2018).

The cultural practices were those recommended by Lopes et al. (2003) for mango cultivation under the conditions of the study region, including pruning, nutritional management via fertigation, harvest point, and control of invasive plants, pests, and diseases.

Throughout the experiment, nutrients were supplied to the plants via fertigation. During the plant cycle, the applied amounts were: 1,480 g nitrogen in the form of urea (45% nitrogen) and calcium nitrate (14% nitrogen), 515 g calcium from calcium nitrate (28% calcium), 631 g magnesium from magnesium sulfate (14% magnesium), 674 g potassium in the form of potassium sulfate (51% potassium), and 645 g phosphorus from monoammonium phosphate (48% P_2O_5). In addition to the mentioned fertilizers, 96 mL fulvic acids (1.0 L ha^{-1}) were added, containing 10% organic carbon, 11% nitrogen, 1.0% K_2O, 6.0% phosphorous acid, and 33% fulvic acid.

Micronutrients were provided by biweekly foliar sprays using a complete fertilizer, containing 10% nitrogen, 8.0% P_2O_5, 8.0% K_2O, 1.0% calcium, 0.5% magnesium, 0.5% boron, 0.2% copper, and 0.5% manganese and zinc.

The experimental design was randomized complete blocks in a 2×3 factorial arrangement, corresponding to the two Israeli mango cultivars (Omer and Shelly) and the number of branches left after formative pruning (three, four, and five branches), with four replicates and five plants per plot, in an experimental area of 2,160 m^2.

The first pruning and topping of the plants were performed below the third node and at a height of 0.7 m above ground level, on 12/28/2018, 189 days after transplanting (DAT). For the first formation pruning of cultivars Omer and Shelly, stems were selected on 1/21/2019, at 213 DAT, and, subsequently, pruned on 3/27/2019 and 4/5/2019, at 247 and 256 DAT, respectively. To determine the effects of formative pruning, biometric, biochemical, and photosynthetic exchange variables were simultaneously evaluated at 31 days after the third pruning on 7/30/2019, at 39 days after the fourth pruning on 11/19/2018, at 22 days after the fifth pruning on 1/10/2020, and at 31 days after the sixth pruning on 7/7/2020.

The following biometric variables were analyzed from the third pruning onwards: number of shoots emitted per branch after each formative pruning; number of newly mature leaves in the last vegetative flow of each branch where the formative pruning was performed; branch diameter, measured using a digital caliper; and crown volume, obtained with the equation $[((L/2) \times (E/2) \times \pi) \times (A)]/3$, where $\pi = 3.1416$, L is the superior distance between branches, E is the mean thickness of the two branches, and A is crown height (Rossi et al., 2004).

Regarding the biochemical variables, the indexes of chlorophyll *a*, *b*, and total, expressed in the leaf chlorophyll index (Falker chlorophyll index, FCI), were measured between 7 and 9 a.m. using the CFL1030 ClorofiLOG chlorophyll meter (Falker, Porto Alegre, RS, Brazil). Total soluble carbohydrate contents were determined in mature leaves from the penultimate vegetation flow, following the methodology described in Dubois et al. (1956), whereas soluble starch in the branches was determined by the method of Hodge & Hofreiter (1962).

Photosynthetic exchanges were measured between 9 and 11 a.m. in the same leaves selected for biochemical determination, using the Li-6400XT infrared gas analyzer (Li-COR Biosciences, Lincoln, NE, USA), coupled to the Li-6400XT portable frequency-modulated light fluorometer (Li-COR Biosciences, Lincoln, NE, USA), at 1,500 μmol photons per square meter per second (artificial light source). These exchanges were expressed by the variables net photosynthesis (*A*), stomatal conductance (*gs*), internal CO_2 concentration (*Ci*), transpiration (*E*), and water use efficiency (WUE = *A*/*E*).

The data were tested for normal distribution and homogeneity of variance using Shapiro-Wilk's test. Subsequently, the analysis of variance was performed using the F-test, at 5% probability. The means referring to the Israeli cultivars and the number of branches after formation pruning were compared by Tukey's test, 5% probability. The data were analyzed with the R statistical software (R Core Team, 2022).

Results and Discussion

The biometric variables were more influenced by the Israeli cultivars, which differed significantly from the third to sixth formative pruning, than by number of branches (Table 1). However, number of branches had a significant effect on number of shoots in the third pruning, shoot length in the fifth pruning, and crown volume in the third to fifth pruning.

Cultivar Omer was superior to Shelly for all biometric variables, except for shoot length between the fourth and sixth formative pruning. The obtained results indicate that the Omer cultivar has a denser and more robust crown due to the presence of more shoots and leaves, whereas Shelly has a more vertical growth characteristic. This is an interesting finding since, although Shelly is not a new cultivar, there are no known studies on its growth habit. This is not the case, however, for cultivar Omer, which showed a greater vigor and leaf area when compared with cultivars Aya, Katuri, and Maya in Egypt, as well as a higher yield in the first year (Haseeb et al., 2020).

According to Gollan & Aro (2020), a large leaf area is associated with a greater potential for capturing light for photosynthesis under ideal water, light, and nutrient conditions, increasing carbohydrate production for the formation of organs, such as fruits.

Regarding the number of branches after each formative pruning, the maintenance of three branches resulted in a higher number of shoots and longer shoot length after the third and fifth formative pruning, respectively. In addition, branch diameter, shoot length, and leaf number differed in the last vegetative flow, which could be attributed to plant development stage, prevailing air temperature, water availability, plant vigor, cultivar, and several other external and internal factors (Kavati, 2004). Cultivar Omer was more vigorous than Shelly after all pruning regarding branch diameter, but only up to the third pruning for number of branches.

Table 1. Analysis of variance and mean test for the biometric variables of the Omer and Shelly Israeli mango (*Mangifera indica*) cultivars as a function of number of branches after each formative pruning(1).

Source of variation	Diameter (mm)	Shoot length (cm)	Number of leaves	Crown volume (m^3)	Number of shoots
			Third prunning		
Cultivars	2.15ns	71.88*	63.53*	36.24*	103.88*
Omer	7.43a	19.85a	4.67a	0.002a	4.46a
Shelly	7.24a	16.77b	3.14b	0.001b	2.71b
Branches	2.54ns	4.25ns	4.39ns	5.38*	8.55*
Three	7.54a	19.01a	4.31a	0.001a	4.81a
Four	7.30a	18.21a	3.73a	0.002ab	3.38b
Five	7.21a	17.72a	3.68a	0.001b	3.28b
Cultivars × branches	0.62ns	0.21ns	0.60ns	1.61ns	4.05*
			Fourth prunning		
Cultivars	9.58*	11.13*	182.96*	14.33*	0.81ns
Omer	14.23a	6.15b	5.66a	0.007a	2.65a
Shelly	13.02b	6.55a	3.72b	0.004b	2.55a
Branches	2.72ns	5.06ns	0.56ns	34.24*	2.29ns
Three	14.18a	6.61a	4.63a	0.009a	2.75a
Four	13.62a	6.25a	4.65a	0.001b	2.59a
Five	13.06a	6.18a	4.81a	0.007a	2.46a
Cultivars × branches	3.26ns	0.03ns	3.14ns	1.87ns	0.18ns
			Fifth prunning		
Cultivars	0.49ns	11.13*	0.48ns	23.24*	2.67ns
Omer	12.60a	6.15b	7.62a	0.013a	3.24a
Shelly	12.39a	6.55a	8.56a	0.009b	3.06a
Branches	1.15ns	5.05*	1.1ns	7.35*	0.17ns
Three	12.66a	6.61a	7.21a	0.013a	3.15a
Four	12.65a	6.25b	7.58a	0.011ab	3.11a
Five	12.18a	6.18b	9.51a	0.009b	3.18a
Cultivars × branches	1.52ns	0.03ns	0.89ns	0.46ns	4.12*
			Sixth prunning		
Cultivars	9.62*	11.21*	2.51ns	24.55*	3.85ns
Omer	9.65a	6.15b	5.89a	0.24a	4.05a
Shelly	8.61b	6.55a	5.43a	0.16b	4.53a
Branches	0.95ns	5.06ns	0.34ns	1.81ns	0.86ns
Three	8.80a	6.61a	5.62a	0.222a	4.06a
Four	9.35a	6.25b	5.83a	0.202a	4.44a
Five	9.23a	6.18b	5.54a	0.185a	4.36a
Cultivars × branches	0.06ns	0.02ns	0.42ns	2.21ns	1.4ns

(1)Means followed by different letters differ by Tukey's test, at 5% probability. ** and *Significant at 1 and 5% probability, respectively. nsNonsignificant.

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Crown volume was influenced by the factor number of branches from the third to fifth formative pruning, being larger for cultivar Omer, which had more shoots and leaves. For this variable, plants with three branches showed higher values than those with five branches after the third and fifth formative pruning and with four branches after the fourth formative pruning.

For number of shoots, a significant difference was only observed after the third pruning, with higher values for cultivar Omer. Moreover, the third and fifth formative pruning showed an interaction between cultivar and number of branches for this variable (Figure 1). After the third formative pruning, cultivar Omer had a higher number of shoots, regardless of the number of branches, whereas Shelly presented a higher number of shoots when it had three branches (Figure 1 A). After the fifth formative pruning, the highest number of shoots was reached when cultivar Omer had four branches. However, the number of branches alone did not affect the number of shoots for both mango cultivars (Figure 1 B).

Leaf chlorophyll content was higher for cultivar Shelly after the third formative pruning, whereas the chlorophyll index showed an opposite behavior after the fourth and sixth pruning, with higher values for cultivar Omer (Table 2). This is explained by the chlorophyll homeostasis that occurs as a phenotypic response to the environmental and management conditions to which the plants are exposed (Dhami et al., 2022). The aforementioned result is associated with the biometric variables since cultivar Omer not only has a higher vegetative vigor but also a higher capacity to synthesize chlorophyll pigments after the fourth pruning (Table 1). Therefore, the Omer cultivar is better adapted to the growing environment, as high chlorophyll *a* contents represent a key physiological adaptation for the high photosynthetic efficiency of plants (Luo et al., 2019). According to Dhami et al. (2022), pigment homeostasis is directly affected by the genetic trait of the plant, which tends to change metabolic pathways to maintain leaf chlorophyll content.

The leaf chlorophyll *a* index was influenced by the interaction cultivar × number of branches after the sixth formative pruning (Figure 2). This finding shows that cultivar Omer had the highest chlorophyll index, regardless of the number of branches. Comparing number of branches, the FCI was the highest for cultivar Omer with four branches, but did not differ significantly among the different number of branches for Shelly.

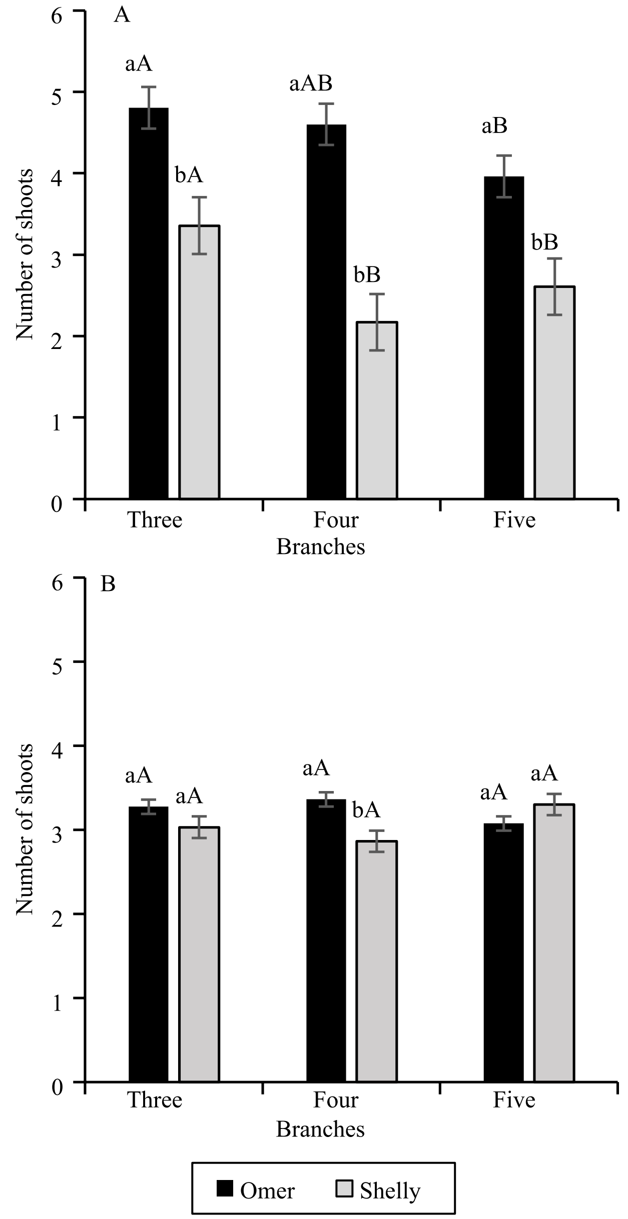

Figure 1. Number of shoots in the third (A) and fifth (B) formative pruning of the Omer and Shelly Israeli mango (*Mangifera indica*) cultivars as a function of number of branches. Bars with the same lowercase letters do not differ for cultivars Omer and Shelly within each number of branches after formative pruning. Bars with the same uppercase letters do not differ for number of branches within each Israeli mango cultivar by Tukey's test, at 5% probability.

Despite the varying leaf chlorophyll indices of the Israeli mango cultivars, similar effects were expected for the contents of carbohydrate starch in the branches. Starch and total soluble carbohydrates did not differ between both cultivars in the third pruning (Table 2). In addition, the highest starch contents of 0.208 and 0.129 µg g^{-1} fresh matter of cultivars Omer and Shelly were found in the fourth formative pruning, coinciding with the moment of the lowest number of shoots, i.e., 2.65 and 2.55, respectively (Table 1).

Therefore, after the third formative pruning, there was a lack of starch response with the increase in leaf chlorophyll content, which could be attributed to the greater development of shoots, considered drains of high energy demand (Richardson et al., 2021). In this scenario, plants need to maintain high levels of photosynthetic rates after pruning to meet the demand for energy (sugars) necessary for the formation of new reproductive structures (Lopes et al., 2021; Sanches et al., 2023).

Table 2. Analysis of variance and mean test for the biochemical variables of the Omer and Shelly Israeli mango (*Mangifera indica*) cultivars as a function of number of branches after each formative pruning[(1)].

Source of variation	Falker chlorophyll index (FCI)			Starch (µg g^{-1} fresh mass)	Carbohydrates (mmol g^{-1} fresh mass)
	Chlorophyll *a*	Chlorophyll *b*	Total chlorophyll		
			Third prunning		
Cultivars	14.87*	8.15*	13.67*	0.85^{ns}	2.77^{ns}
Omer	37.67b	16.02b	53.71b	0.147a	152.84a
Shelly	39.53a	18.37a	57.91a	0.137a	197.95a
Branches	1.09^{ns}	1.22^{ns}	1.51^{ns}	0.93^{ns}	0.46^{ns}
Three	38.2a	16.67a	54.88a	0.152a	179.34a
Four	38.54a	16.81a	55.35a	0.133a	188.96a
Five	39.06a	18.11a	57.17a	0.142a	157.89a
Cultivars × branches	0.13^{ns}	0.98^{ns}	0.74^{ns}	0.89^{ns}	0.47^{ns}
			Fourth prunning		
Cultivars	219.91*	0.46^{ns}	40.14*	5.2*	1.71^{ns}
Omer	46.42a	14.16a	60.58^{a}	0.208a	204.78a
Shelly	38.9b	13.54a	52.44b	0.129b	225.27a
Branches	0.15^{ns}	0.32^{ns}	0.29^{ns}	0.792^{ns}	1.25^{ns}
Three	42.47a	13.61a	56.08^{a}	0.199a	197.45a
Four	42.67a	14.36a	57.19^{a}	0.152a	223.03a
Five	42.83a	13.57a	56.24^{a}	0.154a	224.61a
Cultivars × branches	0.28^{ns}	0.05^{ns}	0.06^{ns}	0.41^{ns}	3.62^{ns}
			Fifth prunning		
Cultivars	0.03^{ns}	0.09^{ns}	0.06^{ns}	2.78^{ns}	3.92^{ns}
Omer	43.81a	18.91a	62.71a	0.173a	235.01a
Shelly	43.83a	18.61a	62.44a	0.147a	204.04a
Branches	0.53^{ns}	0.64^{ns}	0.43^{ns}	5.68*	2.14^{ns}
Three	43.84a	18.16a	62.00a	0.195a	196.97a
Four	43.68a	19.53a	63.22a	0.133b	234.18a
Five	43.93a	18.57a	62.51a	0.153ab	227.44a
Cultivars × branches	2.00^{ns}	0.21^{ns}	0.39^{ns}	0.12^{ns}	0.07^{ns}
			Sixth prunning		
Cultivars	118.31*	0.021^{ns}	33.58*	1.81^{ns}	0.1^{ns}
Omer	43.01a	22.53a	65.54a	0.16a	204.96a
Shelly	35.35b	22.41a	57.75b	0.15a	202.01a
Branches	3.84*	0.001^{ns}	1.0^{ns}	5.01*	5.41*
Three	39.13ab	22.43a	61.57a	0.18a	220.65a
Four	40.41a	22.48a	62.87a	0.13b	183.41b
Five	38.01b	22.48a	60.49a	0.15ab	206.41ab
Cultivars × branches	4.75*	0.79^{ns}	2.36^{ns}	0.26^{ns}	0.35^{ns}

[(1)]Means followed by different letters differ by Tukey's test, at 5% probability. ** and *Significant at 1 and 5% probability, respectively. ^{ns}Nonsignificant.

Regarding number of branches, in general, the mango cultivars grown in the São Francisco Valley region (Keitt, Kent, Haden, and Tommy Atkins) are shaped by leaving three branches for crown opening, fruit mass distribution, and phytosanitary management (Kavati, 2004; Anuário..., 2020). However, further researches are necessary on the production of carbohydrates during the development of the mango canopy, an essential subsidy for tissue formation.

Three branches can also be recommended for the studied Israeli cultivars when considering the starch and carbohydrate contents after the fifth and sixth formative pruning, respectively. With three branches, the plants from both cultivars produced more starch and carbohydrates than those with four, but similar amounts to those with five branches after the fifth and sixth formation pruning, respectively. Therefore, the relationship between number of branches and the production of organic solutes in mango was not completely elucidated.

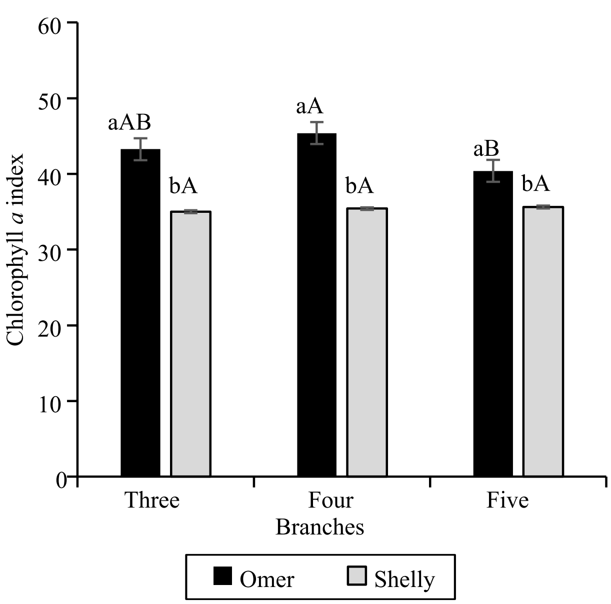

Figure 2. Chlorophyll *a* index of leaves of the Omer and Shelly Israeli mango (*Mangifera indica*) cultivars as a function of number of branches after the sixth formative pruning. Bars with the same lowercase letters do not differ for cultivars Omer and Shelly within each number of branches after formative pruning. Bars with the same uppercase letters do not differ for number of branches within each Israeli mango cultivar by Tukey's test, at 5% probability.

The interaction between cultivars and number of branches is possibly related to the fact that the plants were in the final process of crown formation in the sixth pruning, when an intense branch reduction was no longer needed (Sanjay et al., 2010). Du Toit et al. (2020) highlighted that there is a tendency to favor the rapid growth of vegetative structures, largely due to the presence of more mature leaves with a higher chlorophyll accumulation.

Furthermore, mango is a C3 photosynthetic cycle plant that does not have mechanisms for CO_2 contraction, which leads to an energy loss due to the oxygenase activity in Rubisco (photorespiration) under adverse conditions (Beerling & Royer, 2011). Therefore, the higher the chlorophyll content, the better the plant will adapt to tropical conditions since it can more efficiently absorb light energy in a shorter period, which, in theory, explains the greater vigor of cultivar Omer (Table 2). This cultivar showed higher values of *A*, *gs*, *Ci*, and WUE (Table 3), as well as superiority in photosynthesis in the fourth formative pruning and in WUE until the fifth formative pruning.

For cultivar Tommy Atkins in tropical semiarid conditions, Mudo et al. (2020) concluded that high transpiration rates and internal CO_2 concentrations are positively related to good plant development, although the observed WUE was low. For the Palmer cultivar, Souza et al. (2016) found that the reduction in transpiration is associated with an increased stomatal resistance and, therefore, with water limitation. In the present study, there was no significant difference between cultivars regarding transpiration until the fifth pruning, indicating that the higher WUE of Omer is related to its greater photosynthetic activity with a lower water use, a desired condition for crops in semiarid regions (Li et al., 2022). Cultivar Shelly had a lower and slower adaptive response in the semiarid region of the São Francisco Valley, showing higher values of *A*, g*s*, *E*, and WUE only after the sixth formative pruning.

A significant effect of number of branches was only observed in the fourth formative pruning, with increments in C*i* and WUE in plants with five branches (Table 3). These plants showed a higher internal CO_2 concentration than those with four branches but did not differ significantly from those with three.

In general, the number of branches had little influence on gas exchange, except for *Ci* in the fourth

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pruning and *gs* without pruning. This effect was considered isolated because these two variables have a strong relationship since stomatal opening and closing (*gs*) regulate the entry of carbon into plants (*Ci*) (Carreiro et al., 2022).

In the present study, the Omer mango cultivar presented a faster acclimatization process between the third and fifth pruning, mainly because there was no stomatal limitation in the CO_2 inflow and the photosynthesis rate was maintained at high levels, which, associated with water loss control, led to a higher WUE by the plants (Carreiro et al., 2022). Considering that the environmental conditions of the experimental site were similar, the higher WUE presented by cultivar Omer in the third to the fifth formative pruning is another indicative of its greater acclimatization capacity to the São Francisco Valley in comparison with Shelly (Figure 3). However, in

Table 3. Analysis of variance and mean test for gas exchange of the Omer and Shelly Israeli mango (*Mangifera indica*) cultivars as a function of number of branches after each formative pruning[(1)].

Source of variation	*A*	*gs*	*Ci*	*E*	WUE
	------------------------------(μmol CO_2 m^{-2} s^{-1})------------------------------			(mmol H_2O m^{-2} s^{-1})	(μmol CO_2 $mmol^{-1}$ H_2O)
			Third prunning		
Cultivars	1.076^{ns}	11.77*	18.58*	0.12^{ns}	46.26*
Omer	17.83a	0.24a	252.01a	3.87a	0.06a
Shelly	18.53a	0.19b	216.14b	3.92a	0.05b
Branches	0.35^{ns}	0.81^{ns}	1.24^{ns}	0.23^{ns}	2.05^{ns}
Three	18.56a	0.21a	226.72a	3.94a	0.05a
Four	18.07a	0.23a	232.88a	3.92a	0.06a
Five	17.93a	0.21a	242.62a	3.84a	0.05a
Cultivars × branches	0.029^{ns}	0.07^{ns}	0.244^{ns}	0.30^{ns}	0.08^{ns}
			Fourth prunning		
Cultivars	11.14*	7.17*	0.153^{ns}	1.32^{ns}	41.00*
Omer	15.58a	0.16a	213.59a	6.19a	0.03a
Shelly	12.45b	0.13b	217.19a	5.81a	0.02b
Branches	1.77^{ns}	0.09^{ns}	4.41*	1.09^{ns}	6.59*
Three	13.56a	0.15a	220.90ab	6.34a	0.02b
Four	15.25a	0.14a	196.57b	5.77a	0.02ab
Five	13.24a	0.15a	228.71a	5.88a	0.03a
Cultivars × branches	3.96^{ns}	1.08^{ns}	1.23^{ns}	1.12^{ns}	1.24*
			Fifth prunning		
Cultivars	0.038^{ns}	2.25^{ns}	12.96*	0.17^{ns}	6.54*
Omer	18.39a	0.17a	203.26a	4.68a	0.04a
Shelly	18.59a	0.16a	186.52b	4.57a	0.03b
Branches	0.03^{ns}	0.63^{ns}	2.63^{ns}	0.41^{ns}	0.11^{ns}
Three	18.66a	0.175a	199.84a	4.79a	0.04a
Four	18.46a	0.163a	187.51a	4.48a	0.04a
Five	18.35a	0.171a	197.33a	4.61a	0.04a
Cultivars × branches	2.38^{ns}	1.74^{ns}	3.42^{ns}	1.73^{ns}	1.00^{ns}
			Sixth prunning		
Cultivars	30.57*	6.43*	0.05^{ns}	22.30*	2.95^{ns}
Omer	13.03b	0.11b	176.66a	2.89b	0.04a
Shelly	16.93a	0.14a	179.96a	4.19a	0.03a
Branches	1.33^{ns}	0.41^{ns}	0.36^{ns}	0.8^{ns}	0.21^{ns}
Three	14.21a	0.12a	180.36a	3.33a	0.04a
Four	15.16a	0.12a	169.48a	3.54a	0.03a
Five	15.58a	0.13a	185.10a	3.75a	0.04a
Cultivars × branches	3.02^{ns}	0.53^{ns}	0.08^{ns}	1.22^{ns}	0.08^{ns}

[(1)]Means followed by different letters differ by Tukey's test, at 5% probability. *A*, net photosynthesis; *gs*, stomatal conductance; *Ci*, internal CO_2 concentration; *E*, transpiration; and WUE, water use efficiency. ** and *Significant at 1 and 5% probability, respectively. [ns]Nonsignificant.

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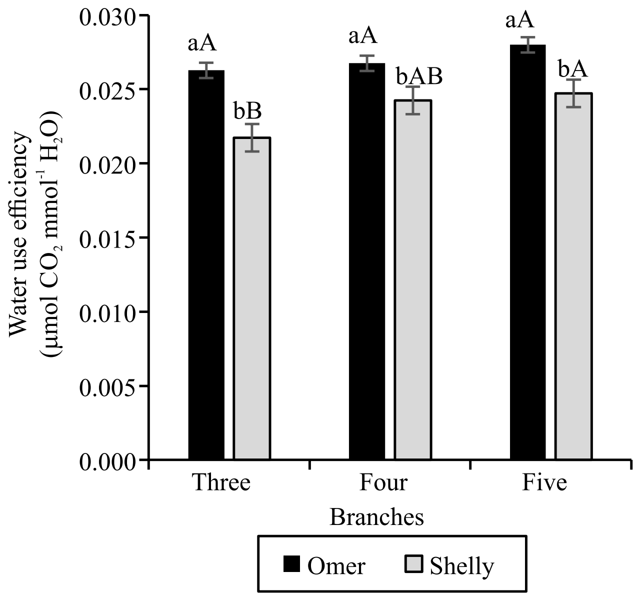

Figure 3. Water use efficiency values for the Omer and Shelly Israeli mango (*Mangifera indica*) cultivars as a function of number of branches after the fourth formative pruning. Bars with the same lowercase letters do not differ for cultivars Omer and Shelly within each number of branches after formative pruning. Bars with the same uppercase letters do not differ for number of branches within each Israeli mango cultivar by Tukey's test, at 5% probability.

the sixth pruning, both cultivars showed the same efficiency, indicating that Shelly, even if later, can adapt as well as Omer regarding WUE. Moreover, cultivar Omer presented the highest WUE under all number of branches after the fourth formative pruning, which shows that the number of branches had little influence on the photosynthetic efficiency of the plant in relation to water vapor losses.

Conclusions

1. The Shelly and Omer Israeli mango (*Mangifera indica*) cultivars show a good development during formation pruning under the growing conditions of the semiarid São Francisco Valley, Brazil.

2. Cultivar Omer is more vigorous for the conditions of the São Francisco Valley, but Shelly is able to adapt later regarding water use efficiency.

3. The formative pruning with three, four, and five branches is indicated for mango cultivars Omer and Shelly under the cultivation conditions of the São Francisco Valley.

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