Revista Macambira

High-depth irrigation stimulates the vegetative growth of *Myrteola nummularia* established in the central-southern zone of Chile

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ABSTRACT

Understanding the water requirements of fruit species is essential due to global water scarcity. In Chile, there are native species with antioxidant-rich fruits, such as *Myrteola nummularia*, which are found in the wild and whose physiological and morphological behaviour in response to irrigation has not been studied. The effect of different irrigation levels (T1: 0%, T2: 50%, T3: 100%, and T4: 150% of daily reference evapotranspiration – ET_0) applied between September 2022 and March 2023 on *M. nummularia* established in Chile was evaluated. Various physiological and vegetative growth variables were analysed. In terms of physiological variables, no significant differences were observed during the day, although there were some specific variations. At 15:00, stomatal conductance was 46.6% and 52.7% higher under 150% ETo compared to 50% and 100% ETo. At 09:00, the maximum quantum yield of photosystem II was 11.5% higher with 0% ETo than with 50% ETo. The chlorophyll index did not show significant differences. In vegetative development, the highest doses (100% and 150% ETo) significantly increased height compared to no irrigation, with increases of 71.9% and 66.2%, respectively. However, the 150% ETo treatment significantly reduced branch length compared to 100% and 50% ETo, being 58.9% and 59.6% lower. It was concluded that irrigation at 100% ETo enables adequate leaf development and efficient water use to establish young *M. nummularia* orchards as a new fruit alternative for central-southern Chile.

Keywords: Photosynthesis, Stomatal conductance, Chlorophyll, Water deficit.

A irrigação em altas doses estimula o crescimento vegetativo da *Myrteola nummularia* estabelecida na zona centro-sul do Chile

ABSTRACT

Conhecer as necessidades hídricas das espécies frutíferas é fundamental devido à escassez a nível mundial. No Chile, existem espécies nativas com frutos ricos em antioxidantes, como a Myrteola nummularia, que se encontram em estado selvagem e cujo comportamento fisiológico e morfológico face à irrigação ainda não foi estudado. Foi avaliado o efeito de diferentes níveis de irrigação (T1: 0%, T2: 50%, T3: 100% e T4: 150% da evapotranspiração de referência diária – ET_0) aplicados entre setembro de 2022 e março de 2023 em M. nummularia estabelecida no Chile. Foram analisadas diversas variáveis fisiológicas e de crescimento vegetativo. Em relação às variáveis fisiológicas, não foram observadas diferenças significativas durante o dia, embora tenham ocorrido algumas variações pontuais. Às 15h, a condutância estomática foi 46,6% e 52,7% maior sob 150% ETo em comparação com 50% e 100% ETo. Às 9h, o rendimento quântico máximo do fotossistema II foi 11,5% maior com 0% ETo do que com 50% ETo. O índice de clorofila não apresentou diferenças significativas. No desenvolvimento vegetativo, as doses mais altas (100% e 150% ETo) aumentaram significativamente a altura em relação à ausência de irrigação, com aumentos de 71,9% e 66,2%, respectivamente. No entanto, o tratamento com 150% ETo reduziu significativamente o comprimento dos ramos em relação a 100% e 50% ETo, sendo 58,9% e 59,6% menor.

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ISSN: 2594-4754 | **DOI:** https://doi.org/10.35642/rm.v9i1.1693.

Concluiu-se que a irrigação a 100% ETo permite um desenvolvimento foliar adequado e um uso eficiente da água para estabelecer pomares jovens de M. nummularia como uma nova alternativa frutícola para o centro-sul do Chile.
Keywords: Fotossíntese, Condutância estomática, Clorofila, Déficit hídrico.

El riego en altas dosis estimula el crecimiento vegetativo de *Myrteola nummularia* establecida en la zona centro-sur de Chile

RESUMEN

Conocer las demandas hídricas de especies frutales es fundamental por la escasez a nivel mundial. En Chile, existen especies nativas con frutos ricos en antioxidantes, como *Myrteola nummularia*, que se encuentran en estado silvestre y cuyo comportamiento fisiológico y morfológico frente al riego no ha sido estudiado. Se evaluó el efecto de diferentes niveles de riego (T1: 0 %, T2: 50 %, T3: 100 % y T4: 150 % de la evapotranspiración de referencia diaria – ET_0) aplicados entre septiembre de 2022 y marzo de 2023 sobre *M. nummularia* establecida en Chile. Se analizaron diversas variables fisiológicas y de crecimiento vegetativo. En cuanto a variables fisiológicas, no se observaron diferencias significativas durante el día, aunque sí algunas variaciones puntuales. A las 15:00 h, la conductancia estomática fue 46,6% y 52,7% mayor bajo 150% ETo en comparación con 50% y 100% ETo. A las 09:00 h, el rendimiento cuántico máximo del fotosistema II fue 11,5% mayor con 0% ETo que con 50% ETo. El índice de clorofila no presentó diferencias significativas. En el desarrollo vegetativo, las dosis más altas (100% y 150% ETo) aumentaron significativamente la altura respecto a sin riego, con incrementos de 71,9% y 66,2%, respectivamente. Sin embargo, el tratamiento con 150% ETo redujo significativamente la longitud de las ramas frente a 100% y 50% ETo, siendo 58,9% y 59,6% menor. Se concluyó que el riego al 100% ETo permite un adecuado desarrollo foliar y uso eficiente del agua para establecer huertos jóvenes de *M. nummularia* como nueva alternativa frutal para el centro-sur de Chile.
Palabras clave: Fotosíntesis, Conductancia estomática, Clorofila, Déficit hídrico.

INTRODUCTION

Globally, water is scarce, a condition that has been worsened by climate change (İkinci, 2025). At the same time, water is essential for crop production and development. Irrigation allows the optimization of root, vegetative, and physiological development in plants, which in turn improves fruit production in high-value commercial species in Chile (El-Sayed *et al*., 2024). Some strategies to improve water efficiency have involved the modernization of irrigation systems. For example, drip irrigation can save up to 90% of water compared to traditional furrow irrigation (CNR, 2022). In Chile, the use of micro-irrigation systems, including drip irrigation, represents 87% of the total fruit orchard area (INE, 2023).

Another strategy to optimize water use is to gain a deeper understanding of the water requirements of each species by evaluating their effects on plant physiology and vegetative development. In general, it is known that physiological functions and leaf biomass production involve water absorption, which can be efficient depending on the species. In plants sensitive to water deficit, low water availability can lead to cellular damage and slower physiological processes (Su *et al*., 2025). It has been shown that plants subjected to extreme water scarcity exhibit slower physiological development, reduced photosynthesis, and lower aboveground biomass yield (Zhao *et al*., 2020; Qiao *et al*., 2024). However, there are drought-tolerant species that can maintain stable physiological functions and growth even under low irrigation levels. For example, *Berberis microphylla* increased its leaf area index and stomatal conductance by

ISSN: 2594-4754 | **DOI:** https://doi.org/10.35642/rm.v9i1.1693.

45 and 34%, respectively, under 50% reference evapotranspiration (ETo) replacement compared to plants irrigated with 150% ETo (Betancur *et al*., 2022). Nevertheless, information on water requirements and the effects of irrigation on physiological and foliar development in native fruit species with commercial potential, such as *Myrteola nummularia*, remains scarce.

The native species *Myrteola nummularia* (Poir.) O. Berg (*M. nummularia*) produces berries with high concentrations of polyphenols and vitamin C, offering antioxidant and nutritional benefits for human health (Ruiz *et al*., 2013). Additionally, its leaves exhibit antiviral, antimicrobial, and antituberculosis properties (López, 2003; Kerr, 2013). *M. nummularia* has also been shown to grow across a wide longitudinal transect in Chile, ranging from Ñuble and Biobío to southern regions such as Aysén, Magallanes, and the Juan Fernández Archipelago (Salehi *et al.*, 2021), demonstrating its adaptability to different climates. In recent years, interest in cultivating native fruit species in Chile has increased due to their health-promoting characteristics. This includes species such as *Berberis microphylla* and *Aristotelia chilensis*, often referred to as "superfruits" (Pinto *et al*., 2022; Pinto-Morales *et al*., 2022), which are part of a global market valued at 45 billion USD in 2020 (Coherent Market Insights, 2025). However, the overall agronomic management of native species with high nutritional value, such as *M. nummularia*, remains poorly understood.

Given the importance of irrigation as a fundamental agronomic practice for fruit species, especially in relation to plant growth and vegetative development, the objective of this study was to determine the effect of different irrigation levels (0%, 50%, 100%, and 150% of reference evapotranspiration, ETo) on the physiology (chlorophyll index, stomatal conductance, and maximum quantum yield of photosystem II) and vegetative growth (plant height and branch length) of *M. nummularia* during its early growth stage under open-field conditions in south-central Chile. We hypothesized that non-irrigated plants (0% ETo) would withstand the environmental conditions of south-central Chile, as has been the case with other native fruit species such as *Berberis microphylla* (Pinto-Morales *et al*., 2022), but would not significantly improve their physiology or vegetative development. In contrast, we believe that plants receiving the highest irrigation level (150% ETo) would show significantly greater vegetative development than those receiving less irrigation (0%, 50%, and 100% ETo), due to more favorable physiological conditions that mitigate stress. This is supported by the greater vegetative growth observed in wild populations of *M. nummularia* in humid regions such as Los Ríos and Los Lagos (Salehi *et al*., 2021). This study aims to identify the optimal irrigation level for enhancing the physiological and vegetative development of *M. nummularia* by

Revista Macambira, Serrinha (BA), v. 9, n. 1, e091023, Jan.-Dez., 2025
ISSN: 2594-4754 | **DOI:** https://doi.org/10.35642/rm.v9i1.1693.

evaluating leaf temperature, chlorophyll index, stomatal conductance, and growth parameters. This approach seeks to promote the establishment of this species and contribute to food security.

METHODOLOGY

Orchard establishment and soil-climatic conditions of the study site

The *Myrteola nummularia* orchard was established in 2022 at the experimental station of the Universidad Adventista de Chile, located in Tanilvoro, at km 12 from the city of Chillán (36°31' S, 71°54' W, at an elevation of 124 m.a.s.l), Ñuble Region, Chile. The orchard was established by transplanting two-year-old plants obtained from the nursery "La Huella" in the city of Valdivia, Los Ríos Region, Chile (39°77' S, 73°24' W, at an elevation of 14 m.a.s.l).

The orchard was planted with a space of 10 cm within rows and 60 cm between rows. At the time of establishment, an inorganic fertilization was applied, consisting of 150 g of urea (46% N), 200 g of triple superphosphate (46% P), and 200 g of potassium sulfate (50% K_2O). The orchard soil belongs to the Andisol order (Melanoxerand) (USDA, 2014) and was characterized at the time of establishment through a chemical analysis conducted by the Soil and Plant Laboratory of the Universidad de Concepción (Table 1). The study area corresponds to a Csb climate zone (Köppen climate classification system, s.d.).

Table 1. Chemical analysis of soil at 20 cm depth from the orchard located in the Ñuble Region, Chile.

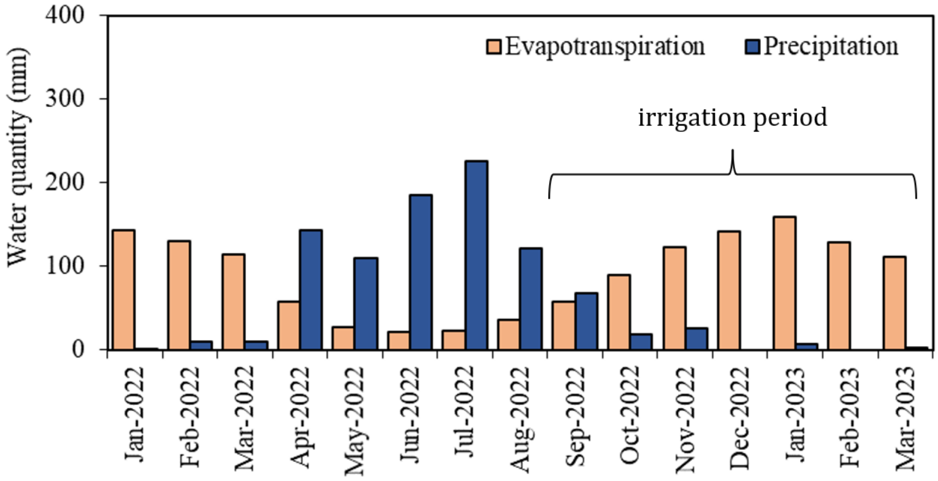
Parameter	Unit	Value
Organic matter	%	11.39
pH		5.77
Available nitrogen (N)	mg kg^{-1}	118.30
Olsen phosphorus (P)	mg kg^{-1}	16.40
Available potassium (K)	mg kg^{-1}	279.60

Source: By the authors, 2025

The climate of the Ñuble Region corresponds to a temperate Mediterranean type, with an average annual temperature of 13.2°C and accumulated precipitation of 920 mm for the year 2022 and up to March 2023. Irrigation periods were carried out between September 2022 and March 2023 (Figure 1).

ISSN: 2594-4754 | **DOI:** https://doi.org/10.35642/rm.v9i1.1693.

Figure 1. Irrigation period, reference evapotranspiration (ETo) and accumulated precipitation for the year 2022 and up to March 2023 in the Ñuble Region, based on data from the agrometeorological station of the Agricultural Research Institute (INIA Santa Rosa), Cato Road, Km 18, Chile.



Source: By the authors.

Experimental design of the experiment

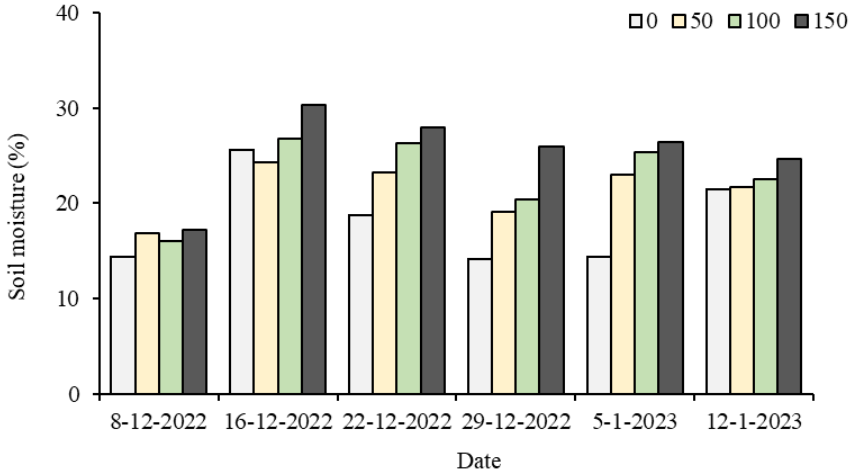
In the *M. nummularia* orchard, four irrigation depths based on replacement of reference evapotranspiration (ETo) were established, namely 0, 50, 100, and 150% ETo. During the irrigation period, the actual daily irrigation depth was calculated monthly using the Penman–Monteith method, following the approach of Betancur *et al*. (2022), with climatic data obtained from the INIA Santa Rosa agroclimatic station, located about 28 km from the study site (AGROMETEOROLOGIA, 2025).

The experimental design was a randomized complete block design. Each experimental unit consisted of an average of two subsamples, with each subsample representing one *M. nummularia* plant. Four replicates per treatment were used (n = 16) across all blocks. Soil volumetric water content (%) was monitored on different dates from December 2022 to January 2023 (Figure 2), by drying soil samples in a Hes model BOV-T50F oven (Health Equipment Supply LTDA, Peñaflor, Chile).

Irrigation treatments were applied using one lateral irrigation line for the 50% ETo treatment, two lines for the 100% ETo treatment, and three lines for the 150% ETo treatment, with UniRam pressure-compensating drippers (Netafim^{TM}, Hatzerim, Israel). The drippers were spaced 50 cm apart and delivering a flow of 2.0 L h^{-1}. The control treatment (0% ETo) did not include any irrigation lines. The daily irrigation time (h day^{-1}) was calculated by dividing the monthly ETo (mm) by the number of irrigation days.

Revista Macambira, Serrinha (BA), v. 9, n. 1, e091023, Jan.-Dez., 2025
ISSN: 2594-4754 | DOI: https://doi.org/10.35642/rm.v9i1.1693.

Figure 2. Soil moisture under different irrigation depths during the experimental period. Treatments 0, 50, 100, and 150 correspond to 0, 50, 100, and 150% of the reference evapotranspiration (ETo), respectively.



Source: By the authors.

Environmental and physiological measurements of the plant

Environmental and physiological parameters of the plants were measured during a sunny, cloudless week on 15 January 2023. At the time of measurement, the irrigation treatments had been applied for 135 days. Measurements were taken at four specific times during the day: 09:00, 12:00, 15:00, and 18:00 h (Retamal-Salgado *et al*., 2017). Physiological measurements were performed on mature, healthy leaves located in the center of the plant and on the middle third of the branches. Direct radiation (photosynthetic photon flux density – PPFD, µmol m^{-2} s^{-1}) was measured using an AccuPAR LP-80 portable ceptometer (Decagon Devices Inc., Washington, DC, USA). Leaf surface temperature (°C) was measured with a CTR1000 handheld infrared thermometer (WIKA Instruments S.A.U., Barcelona, Spain).

Chlorophyll content in leaves was estimated using a portable SPAD (Soil Plant Analysis Development) meter model MC-100 (Apogee Instruments, Logan, UT, USA) (Ribeiro et al., 2015). Stomatal conductance (Gs, mmol m^{-2} s^{-1}) was measured using a portable porometer model SC-1 (Decagon Devices, Washington, DC, USA). Maximum quantum yield of photosystem II (Fv/Fm) was measured with a portable fluorometer model OS-5p (Opti-Sciences, Hudson, NH, USA), after adapting the leaves to darkness for 30 min using a mobile leaf clip (Maxwell; Johnson, 2000).

Morphological measurements of the plant

Plant height and branch length (cm) of *M. nummularia* were measured using a measuring tape. Measurements were taken on January 16, 2023. At the time of measurement, the irrigation treatment application time was 136 days. Plant height was recorded vertically

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from the base to the tip of the longest shoot, while branch length was calculated as the average length of all branches on the plant (Wang; Chen, 2020).

Statistical analysis

The data were subjected to analysis of variance (ANOVA), followed by Fisher's Least Significant Difference (LSD) test ($p = 0.05$) to compare the means. To evaluate the correlation between physiological and morphological variables of *M. nummularia*, a correlation analysis was performed using R Studio (2015), with the packages FactoMineR and ggplot2 (Kahle; Wickham, 2013).

RESULTS AND DISCUSSION

The results supported the initial hypothesis: non-irrigated plants tolerated the environmental conditions of the study site, and higher irrigation levels (100 and 150% of the reference evapotranspiration – ETo) increased plant height (Figure 8) compared to non-irrigated ones. In the wild, it is uncommon to find *M. nummularia* in regions like the study area (Ñuble Region), compared to areas with higher relative humidity and rainfall, such as the Los Ríos Region, where these conditions can be 10 and 100% greater, respectively (AGROMETEOROLOGÍA, 2022). Specifically, the highest irrigation depth (150% ETo) improved stomatal conductance (Figure 6) at peak radiation hours (15:00 h) compared to irrigation depths at 50 and 100% ETo. Both the irrigation depths at 100 and 150% ETo significantly increased plant height compared to the non-irrigated control. These findings are consistent with results in other cultivated and native fruit species. For example, Mousa *et al*. (2025) reported a significant increase in shoot and leaf area in pomegranate plants irrigated at 75 or 100% of crop water requirement compared to those irrigated at 50%, confirming the crucial role of water in plant development.

However, it is noteworthy that the 150% ETo treatment resulted in shorter branches compared with the 50 and 100% ETo treatments. This could have negative implications for productivity, since branches support fruit production, which may decrease if branch size is reduced. This has also been reported by Radunz *et al*. (2018) in Climax blueberry, where branch length significantly influenced the total number of floral and vegetative buds, with longer branches (10–14 cm) producing more buds than shorter ones (6–9 cm). Additionally, this study showed that irrigation was not a key factor for some plant health indicators, such as chlorophyll content, and the physiological and morphological variables evaluated did not show strong correlations with each other. These findings are relevant for the establishment of future *M.*

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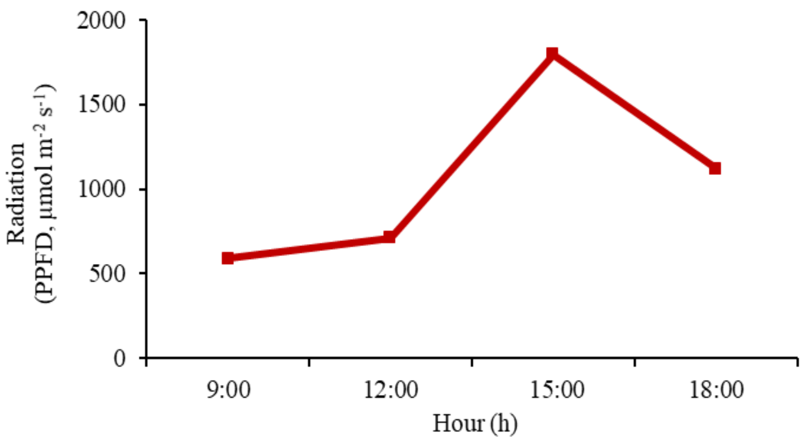
nummularia orchards in south-central Chile, particularly from the perspective of optimizing increasingly scarce water resources.

Environmental and physiological variables of the plant

Solar radiation varied throughout the day (Figure 3), with an initial value of 589 µmol m^{-2} s^{-1} recorded at 09:00 h. It then increased moderately to 711 µmol m^{-2} s^{-1} at 12:00 h and reached its peak at 15:00 h with 1793 µmol m^{-2} s^{-1}. By the final measurement of the day (18:00 h), radiation had decreased to 1120 µmol m^{-2} s^{-1}.

Figure 3. Direct solar radiation at different times (09:00, 12:00, 15:00, and 18:00 h) on a sunny day in the *M. nummularia* orchard located in the Ñuble Region, Chile.



Source: By the authors.

Leaf temperature (Figure 4) began at 24°C at 09:00 h and increased throughout the day, reaching a maximum of 35°C at 15:00 h. It then decreased to 29°C by 18:00 h, following the same pattern as solar radiation (Figure 3). Among the irrigation treatments, significant differences were observed only at 18:00 h, with the 150% ETo treatment being 7% higher than the other treatments. It has been shown that high irrigation depths can saturate the soil and cause root anoxia, reducing functions such as transpiration and allowing residual heat to accumulate in the leaves, increasing leaf temperature (Schymanski; Or, 2016; Moreno *et al.*, 2020). However, this was not the case in the present study, as the highest irrigation depth (150% ETo) did not saturate the soil and the plants maintained higher physiological functions (e.g., stomatal conductance). Additionally, Ruangsangaram *et al.* (2025) noted that irrigation can also induce temporary increases in leaf temperature. Therefore, further research is needed on the effects of irrigation on leaf temperature, including longer measurement periods, as the higher temperature observed at 18:00 h in this study was a single occurrence and not consistent throughout the day.

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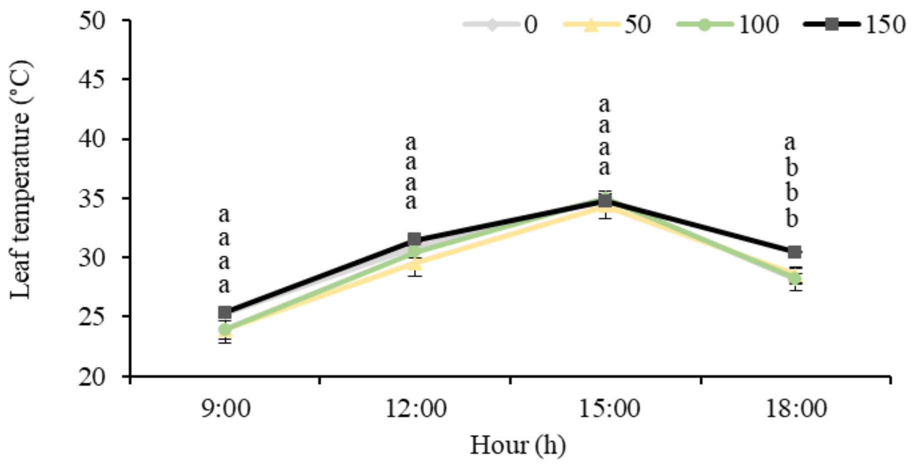
Figure 4. Leaf temperature at different times of the day (09:00, 12:00, 15:00, and 18:00 h) of *M. nummularia* under different irrigation depths based on reference evapotranspiration – ETo (0, 50, 100, and 150% ETo). Different lowercase letters indicate significant differences between treatments according to Fisher's LSD test ($p < 0.05$). Mean ± standard error ($n = 8$). Error bars represent experimental error for each treatment.



Source: By the authors.

The leaf chlorophyll index (SPAD), measured at 09:00, 12:00, 15:00, and 18:00 h (Figure 5), showed an average value of 0.8 SPAD and did not present significant differences among the irrigation treatments (0, 50, 100, and 150% ETo). The chlorophyll index is related to photosynthetic capacity, nitrogen concentration, and the overall physiological status of crops (Wang *et al*., 2021). The lack of significant differences during the day was expected, as longer periods (months or seasons) are required to observe changes in foliar pigments. For example, chlorophyll levels tend to increase during spring compared to other seasons like summer or autumn, when foliar senescence begins (Huang *et al*., 2023). Nevertheless, our results indicate that regardless of irrigation depth, *M. nummularia* plants maintained an adequate nutritional status, likely due to the species' low water and nutrient requirements and/or the high agricultural suitability of the soil at the study site, which was characterized by favorable physical and chemical properties. This is supported by Betancur *et al*. (2024), who established an orchard of the native species *Berberis microphylla* in the Ñuble Region (the same region as in the present study), using soils with favorable physicochemical attributes for plant nutrition.

Stomatal conductance (Figure 6) showed significant differences at 15:00 h, where the 150% ETo treatment was 46.6 and 43% higher than the 50 and 100% ETo treatments, respectively. At 09:00, 12:00, and 18:00 h, no statistical differences were observed among irrigation depths. Similarly, Ohashi *et al*. (2020) reported that irrigation management in sugarcane seedlings using a 96% ETo dose significantly improved stomatal conductance

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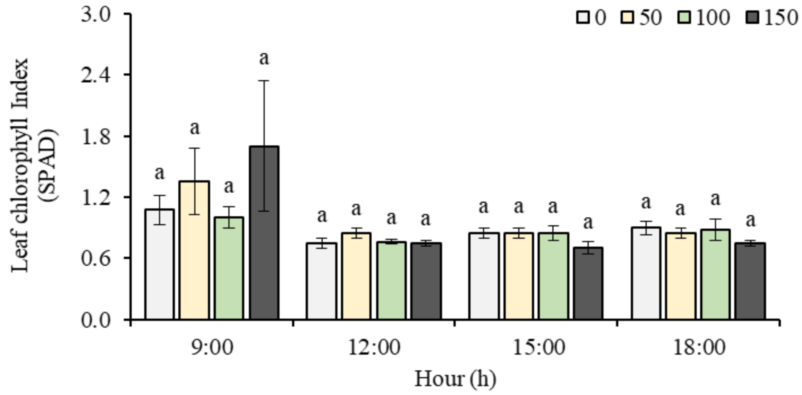
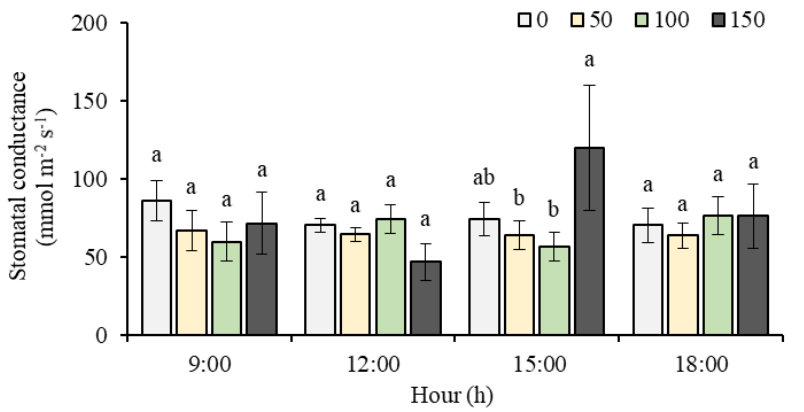
compared to 48 and 68% ETo treatments. It is well known that under environmental stress, plants often respond by partially or fully closing their stomata, thereby reducing gas exchange to limit transpiration and conserve water in the tissues (Jalakas *et al*., 2021). *Myrteola nummularia* demonstrates the ability to keep its stomata open even under adverse atmospheric conditions. In scenarios where water availability is variable or supplemented by irrigation, this strategy could be advantageous, as it enhances both growth and carbon assimilation when water is abundant (Dayer *et al*., 2020). However, compared to other native species such as *Berberis microphylla*, *M. nummularia* was less hardy, as *Berberis microphylla* proved to be more efficient under lower water inputs in the same study region (Betancur *et al*., 2022).

Figure 5. Leaf chlorophyll index (SPAD) at different times of the day (09:00, 12:00, 15:00, and 18:00 h) of *M. nummularia* under different irrigation depths based on reference evapotranspiration – ET_o (0, 50, 100, and 150% ET_o). Different lowercase letters indicate significant differences between treatments according to Fisher's LSD test ($p < 0.05$). Mean ± standard error ($n = 8$). Error bars represent experimental error for each treatment.



Source: By the authors.

Figure 6. Stomatal conductance at different times of the day (09:00, 12:00, 15:00, and 18:00 h) of *M. nummularia* under different irrigation depths based on reference evapotranspiration – ET_o (0, 50, 100, and 150% ET_o). Different lowercase letters indicate significant differences between treatments according to Fisher's LSD test ($p < 0.05$). Mean ± standard error ($n = 8$). Error bars represent experimental error for each treatment.



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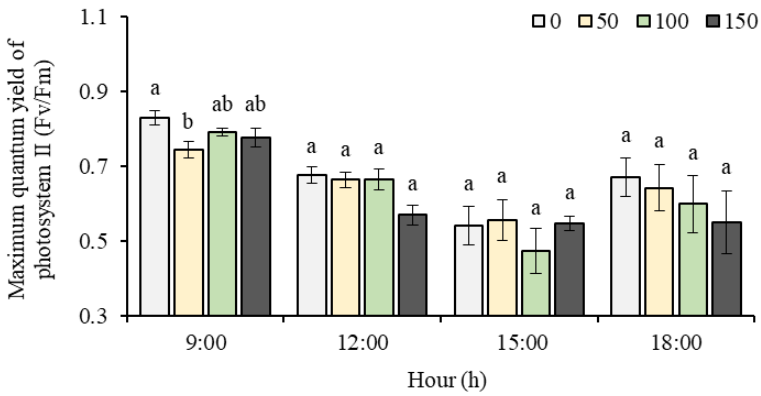
ISSN: 2594-4754 | **DOI:** https://doi.org/10.35642/rm.v9i1.1693.

Regarding the quantum yield of photosystem II (Figure 7), at 09:00 h, the 0% ETo treatment was 10% lower than the 50% ETo treatment, while no significant differences were observed for the other irrigation treatments (100 and 150% ETo). At 12:00, 15:00, and 18:00 h, the quantum yield of photosystem II did not show significant differences among irrigation treatments. A decreasing trend in the quantum yield was observed as the day progressed, reaching its lowest point at 15:00 h, followed by a slight increase at 18:00 h. The maximum quantum yield of photosystem II is an indirect measure of plant photosynthesis (Maxwell; Johnson, 2000). This study showed that values tended to decline throughout the day, but the minimum value observed (0.5) would not be a stress condition, as has been reported in both cultivated and wild fruit species, such as *Prunus domestica* (Calderón Orellana *et al*., 2025) or *Berberis microphylla* (Betancur *et al*., 2022).

Figure 7. Variation in the maximum quantum yield of photosystem II (Fv/Fm) at different times of the day (09:00, 12:00, 15:00, and 18:00 h) of *M. nummularia* under different irrigation depths based on reference evapotranspiration – ET_0 (0, 50, 100, and 150% ET_0). Different lowercase letters indicate significant differences between treatments according to Fisher's LSD test ($p < 0.05$). Mean ± standard error (n = 8). Error bars represent experimental error for each treatment.



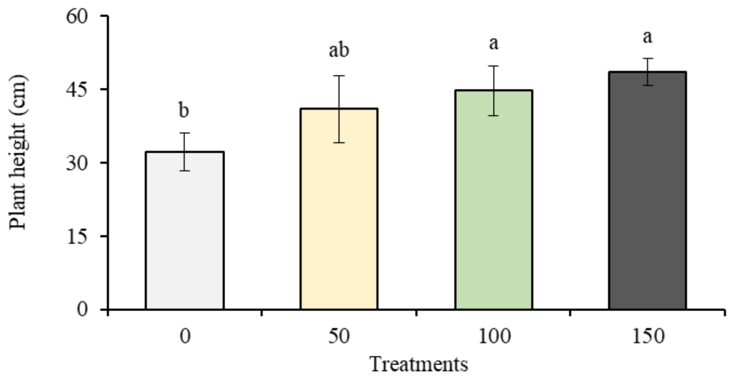
Source: By the authors.

Plant height (Figure 8) did not show significant differences under the 50% ETo treatment compared to the other treatments. However, higher irrigation depths (100 and 150% ETo) significantly promoted plant growth, with plants being 34 and 28% taller, respectively, than those under the non-irrigated control (0% ETo). This positive effect of irrigation on vegetative growth has been reported in various fruit crops. For example, in blueberry (*Vaccinium corymbosum*), plants irrigated with high water volumes (10 L $plant^{-1}$) reached greater heights compared to those receiving lower irrigation (2 L $plant^{-1}$) or no irrigation, with the latter showing up to 11% less growth (Ehret *et al*., 2012). Similarly, Kubo *et al*. (2024) demonstrated that irrigation at 100% field capacity promoted more vigorous vegetative growth in cherry tomato plants, as reflected in plant height, stem diameter, and leaf area, compared to

ISSN: 2594-4754 | **DOI:** https://doi.org/10.35642/rm.v9i1.1693.

irrigation at 90% and 70% field capacity. These results are important because vegetative biomass development, whether defined by greater height, longer branches, or a higher number of leaves, can lead to more flowers and ultimately a greater number of fruits, as reported in crops such as blueberries (Phillips *et al*., 2020).

Figure 8. Plant height of *M. nummularia* under different irrigation depths based on reference evapotranspiration – ET_o (0, 50, 100, and 150% ET_o). Different lowercase letters indicate significant differences between treatments according to Fisher's LSD test ($p < 0.05$). Mean ± standard error (n = 8). Error bars represent experimental error for each treatment.

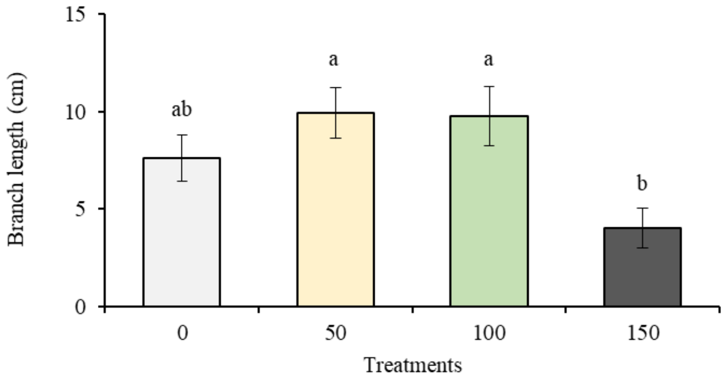


Source: By the authors.

Branch length (Figure 9) was 2.5 and 2.4 times greater in the 50 and 100% ETo treatments, respectively, compared to the 150% ETo treatment. The 0% ETo treatment did not show significant differences compared to the other irrigation treatments. Likely, adequate irrigation depths (50% and 100% ETo) triggered a hormonal balance adjustment that promoted vegetative growth. It has been demonstrated that proper water availability stimulates gibberellin synthesis in apical meristems, promoting cell elongation and shoot growth (Colebrook *et al*., 2014; Castro-Camba *et al*., 2022). Irrigation also stimulates cytokinin production in active roots, which favors cell division and nutrient mobilization toward growing tissues (Fresno; Munné-Bosch, 2023). In this study, the highest irrigation depth (150% ETo) may have disrupted the hormonal balance, possibly leading to increased ethylene production—a hormone that, in high concentrations, inhibits shoot and stem elongation and promotes senescence and abscission responses (Bashar *et al*., 2018; Pan *et al*., 2021). It is known that excess water in the environment promotes downward transport and synthesis of auxins, along with a relative reduction in cytokinins, thereby reconfiguring plant growth architecture (Katyayini *et al*., 2020).

Revista Macambira, Serrinha (BA), v. 9, n. 1, e091023, Jan.-Dez., 2025
ISSN: 2594-4754 | **DOI:** https://doi.org/10.35642/rm.v9i1.1693.

Figure 9. Branch length of *M. nummularia* under different irrigation depths based on reference evapotranspiration – ET_0 (0, 50, 100, and 150% ET_0). Different lowercase letters indicate significant differences between treatments according to Fisher's LSD test ($p < 0.05$). Mean ± standard error (n = 8). Error bars represent experimental error for each treatment.

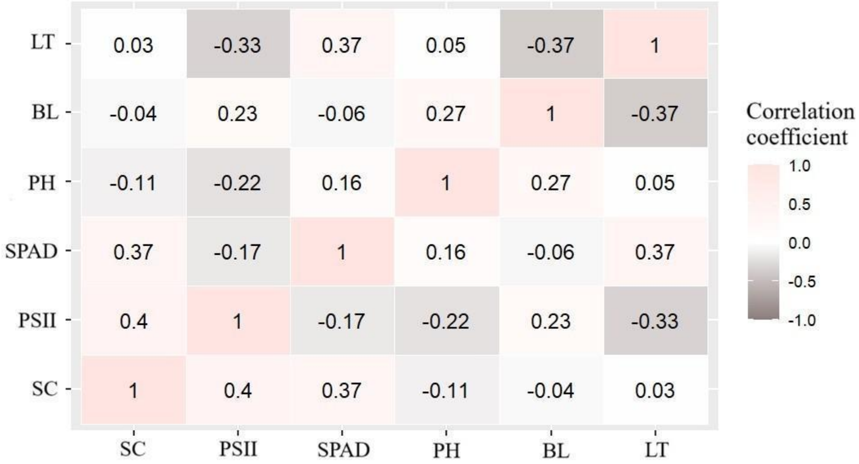


Source: By the authors.

The correlation matrix (Figure 10) showed weak correlations among variables, with Pearson coefficients not exceeding an absolute value of 0.37. However, some slight positive correlation trends were identified, suggesting the influence of environmental conditions and physiological processes on the plant's morphological parameters. For example, stomatal conductance and the maximum quantum yield of photosystem II (coefficient: 0.4), leaf temperature and chlorophyll index (SPAD) (coefficient: 0.37), and plant height and branch length (coefficient: 0.27). On the other hand, weak negative correlations also suggested an effect of environmental conditions and physiological processes on plant morphology, such as between leaf temperature and the maximum quantum yield of photosystem II (coefficient: -0.33), and between the quantum yield of photosystem II and plant height (coefficient: -0.22). Although environmental parameters and plant physiological processes have been shown to influence aboveground biomass survival and performance (Schönbeck *et al*., 2023), it is possible that the short duration of treatment implementation (one season) limited the strength of correlations among the variables studied. In contrast, studies on fruit crops with longer irrigation periods (> one year) have confirmed strong correlations between physiological and morphological factors in native fruit species under irrigation treatments (Betancur *et al*., 2022).

Revista Macambira, Serrinha (BA), v. 9, n. 1, e091023, Jan.-Dez., 2025
ISSN: 2594-4754 | **DOI:** https://doi.org/10.35642/rm.v9i1.1693.

Figure 10. Correlation matrix. BL: branch length; PH: plant height; LT: leaf temperature; PSII: maximum quantum yield of photosystem II; SC: stomatal conductance; SPAD: leaf chlorophyll index.



Source: By the authors.

CONCLUSION

This study demonstrated the effects of irrigation (reference evapotranspiration, ETo) on the physiological and vegetative development of *Myrteola nummularia* was able to tolerate non-irrigated conditions during its early growth stages. Plants that received no water replacement (0% ETo) survived under the soil and climate conditions of the Ñuble Region but showed reduced height and lower physiological performance. However, vegetative development was favored by proper water management (100 and 150% ETo). The highest irrigation depth (150% ETo) improved some physiological parameters, such as stomatal conductance during periods of high radiation, but significantly reduced branch length, which could negatively affect future fruit production. On the other hand, irrigation at 100% ETo promoted greater leaf development, resulting in taller plants with longer branches compared to the 150% ETo treatment, while also saving water. Therefore, the most efficient irrigation level to promote morphological development and optimize water use is 100% ETo. This knowledge is essential for advancing the domestication and cultivation of *M. nummularia* orchards in south-central Chile, a species with high nutritional and functional potential, contributing to fruit diversification under a sustainability-focused approach. Future studies should also address other important management practices for the establishment of *M. nummularia*, such as fertilization, weed control, and pruning, as well as the evaluation of soil parameters, including nutrient availability and biological activity.

ISSN: 2594-4754 | **DOI:** https://doi.org/10.35642/rm.v9i1.1693.

ACKNOWLEDGMENTS

The authors thank the Universidad Adventista de Chile, especially the Department of Agronomy of the Faculty of Engineering and Business, and the Graduate Program in Modern Fruit Growing.

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Revista Macambira

Informações do Artigo	Article Information
Recebido em: 21/07/2025 **Aceito em**: 12/11/2025 **Publicado em**: 19/11/2025	**Received on**: 2025/07/21 **Accepted in**: 2025/11/11 **Published on**: 2025/11/19
Contribuições de Autoria *Resumo*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos *Introdução*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos *Referencial teórico*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos *Análise de dados*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos *Discussãodos resultados*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos *Conclusão*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos *Referências*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos, Yessica Rivas-Tisnao, Fernando Pinto-Morales, Daniela Valecia-Orge *Revisão do manuscrito*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos, Yessica Rivas-Tisnao, Fernando Pinto-Morales, Daniela Valecia-Orge *Aprovação da versão final publicada*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos, Yessica Rivas-Tisnao, Fernando Pinto-Morales, Daniela Valecia-Orge	**Author Contributions** *Abstract/Resumen*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos *Introduction*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos *Theoretical reference*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos *Data analysis*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos *Discussion of results*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos Conclusion: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos *References*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos *Manuscript review*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos, Yessica Rivas-Tisnao, Fernando Pinto-Morales, Daniela Valecia-Orge *Approval of the final published version*: Matías Betancur, Eduardo Alarcón-Troncoso, Andrés Pinto-Poblete, Sergio Moraga-Bustos, Yessica Rivas-Tisnao, Fernando Pinto-Morales, Daniela Valecia-Orge
Conflitos de Interesse Os autores declaram não haver nenhum conflito de interesse de ordem pessoal, comercial, acadêmico, político e financeiro referente a este manuscrito.	**Interest conflicts** The authors declare that there is no personal, commercial, academic, political or financial conflict of interest regarding this manuscript.
Como Citar este artigo - ABNT BETANCUR, Matías *et al*. A irrigação em altas doses estimula o crescimento vegetativo da *Myrteola nummularia* estabelecida na zona centro-sul do Chile. **Revista Macambira**, Serrinha (BA), v. 9, n. 1, e091023, jan./dez., 2023. https://doi.org/10.35642/rm.v9i1.1693.	**How to cite this article - ABNT** BETANCUR, Matías *et al*. High-depth irrigation stimulates the vegetative growth of *Myrteola nummularia* established in the central-southern zone of Chile. **Revista Macambira**, Serrinha (BA), v. 9, n. 1, e091023, jan./dez., 2023. https://doi.org/10.35642/rm.v9i1.1693.