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# Effect of mulches on weed control, physiological performance, and morphology in a murta orchard

## Efecto de mantillos sobre el control de maleza, el rendimiento fisiológico y la morfología en un huerto de murta

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## ABSTRACT

The present study evaluated the effect of different mulches (geotextile, oat stubble, and pine residue) on the physiological performance, morphological traits, weed suppression, and soil moisture of *Ugni molinae* Turcz (murta) plants in an experimental orchard located in the Ñuble Region, Chile. A randomized complete block design with four treatments and four replicates was implemented. Physiological parameters, including the maximum quantum efficiency of photosystem II (Fv/Fm), stomatal conductance, chlorophyll index (SPAD), and leaf temperature, were measured at various times of the day. Morphological variables included plant height, stem count, and stem height. Additionally, soil moisture and weed biomass were recorded, along with multivariate analyses to evaluate variable interactions. The geotextile treatment resulted in significantly higher Fv/Fm values and reduced weed biomass by over 97%, while also maintaining greater soil moisture on key dates compared to the control. No significant differences were observed in morphological parameters. Pearson correlation analyses and Principal Component Analysis revealed strong associations between mulch temperature, soil moisture, and physiological responses. These findings suggest that geotextile mulch contributes to the optimization of physiological performance and weed control in murta cultivation, supporting its potential as a sustainable management strategy for native berry production.

**Keywords:** Andisol; Chile; morphological traits; photosynthetic efficiency; pigments; soil moisture

## RESUMEN

El presente estudio evaluó el efecto de diferentes mulch (geotextil, rastrojo de avena y residuo de pino) sobre el comportamiento fisiológico, los rasgos morfológicos, la supresión de malezas y la humedad del suelo en plantas de *Ugni molinae* Turcz. (murta) establecidas en un huerto experimental ubicado en la región de Ñuble, Chile. Se implementó un diseño de bloques completos al azar con cuatro tratamientos y cuatro repeticiones. Se midieron parámetros fisiológicos, como la eficiencia cuántica máxima del fotosistema II (Fv/Fm), la conductancia estomática, el índice de clorofila (SPAD) y la temperatura foliar, en diferentes momentos del día. Las variables morfológicas incluyeron la altura de planta, el número de tallos y la altura de los tallos. Adicionalmente, se registraron la humedad del suelo y la biomasa de malezas, junto con análisis multivariados para evaluar las interacciones entre variables. El tratamiento con geotextil presentó valores significativamente mayores de Fv/Fm y redujo la biomasa de malezas en más del 97 %, además de mantener una mayor humedad del suelo en fechas clave en comparación con el control. No se observaron diferencias significativas en los parámetros morfológicos. Los análisis de correlación de Pearson y de componentes principales revelaron asociaciones fuertes entre la temperatura del mulch, la humedad del suelo y las respuestas fisiológicas. Estos hallazgos sugieren que el mulch geotextil contribuye a optimizar el desempeño fisiológico y el control de malezas en el cultivo de murta, respaldando su potencial como estrategia de manejo sostenible para la producción de berries nativos.

**Palabras clave:** Andisol; Chile; eficiencia fotosintética; humedad del suelo; pigmentos; rasgos morfológicos

## INTRODUCTION

Mulching is a common practice in agriculture. This practice consists of covering the soil surface with organic and inorganic materials (Frutos *et al*., 2016; Leclercq-Dransart *et al*., 2020). Inorganic mulches include low-density polyethylene, the most widely used in agriculture because of its environmental resistance, elasticity, and impermeability to water (Xu *et al*., 2024). However, polyethylene mulches cause environmental damage, as their recycling is complex and their chemical and biological degradation is limited due to their strong chemical stability and high hydrophobic capacity (Frutos *et al*., 2016; Xu *et al*., 2024).

Organic mulches are presented as a viable alternative to polyethylene-based mulches (Xu *et al*., 2024), fulfilling the same objective of weed control (Iqbal *et al*., 2020). This technique has become a fundamental tool for sustainable crop management, especially in organic agriculture where herbicide use is restricted (Burkhard *et al*., 2009). Palsaniya *et al*. (2024) observed that mulching in maize decreased the weed seed bank and reduced weed density by 50% and weed biomass by 65% compared to bare soil. Frutos *et al*. (2016) mentioned that mulches based on wheat straw and legumes are widely used in different cropping systems for their ability to reduce nitrogen leaching and suppress weeds. Organic mulches also contribute to soil health by providing organic matter, improving soil structure, and enhancing biological activity, which increases the biodiversity of the soil microbiome (Frutos *et al*., 2016; Leclercq-Dransart *et al*., 2020).

In terms of soil conservation, mulching improves water retention and permeability (Al-Qthanin *et al*., 2024). A significant improvement in the rhizosphere temperature of 12-17% was also observed under a herbaceous plant mulch compared to a bare surface which suffered a decrease of only 4% (Leclercq-Dransart *et al*., 2020). The choice of mulching material will depend on various factors, such as soil type, crop type, climate, resources, and farmer preferences (Iqbal *et al*., 2020).

Forest industries often consider waste as some products that in agriculture can be used as mulches (Iqbal *et al*., 2020; Khamare & Marble, 2023), some common wastes, such as pine bark, are used as raw materials to establish mulches in soils, which in turn increase the organic matter content and promote root system development in plants (Al-Qthanin *et al*., 2024; Burkhard *et al*., 2009).

This agronomic practice not only enhances soil structure and fertility but is also particularly relevant in the cultivation of native berry-producing plants, which are increasingly valued for their health-promoting bioactive compounds. In recent years, the consumption of red fruits from native plants has gained relevance due to their high concentrations of phenolic compounds, which are associated with protection against various pathologies, such as cancer (Junqueira-Gonçalves *et al*., 2015). In the Ñuble Region, specifically at the Universidad Adventista de Chile (UnACh), an experimental orchard of calafate (*Berberis microphylla* G. Forst.) has been established, where research is being conducted on its phenolic properties. In addition, the use of organic mulch and its impact on soil health and calafate berries is also being studied (Betancur *et al*., 2023). Along with calafate, other native species have attracted interest due to their agro-industrial potential and their benefits for human health. In this context, murta (*Ugni molinae* Turcz) has been studied for its antioxidant properties and its adaptability to diverse agro-ecological conditions (Castro *et al*., 2021). Studies on berries such as murta have shown that they are an excellent source of polyphenolic antioxidants, similar to those found in blueberry and calafate (Junqueira-Gonçalves *et al*., 2015).

Interest in the production and preservation of murta is due to its high nutritional value and multiple health benefits. In addition, it possesses anti-inflammatory, antimicrobial, and healing properties, which has led to its study in both food and pharmaceutical applications (Junqueira-Gonçalves *et al*., 2015).

As murta grows in soils with high moisture and natural vegetation cover (Pastenes *et al.*, 2003), the use of mulching in its cultivation has become a relevant strategy for improving its development. In this sense, mulches can influence key parameters such as soil temperature, moisture retention, and weed control (Frutos *et al.*, 2016). Thus, the study of the effect of different types of mulching on murta is essential to optimize its production and contribute to its conservation in controlled agricultural environments.

Therefore, this study aimed to investigate the impacts on physiological aspects of *Ugni molinae* Turcz and weed control efficiency, using different types of mulch (geotextile, wheat stubble, and chipped pine residues), under the hypothesis that the use of mulches, both organic and inorganic, improves the physiological efficiency of *Ugni molinae* Turcz, without compromising the morphological development of the plant.

## MATERIALS AND METHODS

### *Study area*

The study was conducted in an experimental orchard established at the end of at the experimental station of the Universidad Adventista de Chile (UnACh), on the road to Las Mariposas number 11771, Chillán Province, Ñuble Region (36° 38'S latitude, 72° 00'W longitude and 189 m.a.s.l.). The soil is of volcanic origin and belongs to the andisol order (Typic Melanoxerand) (Soil Survey Staff, 2022). The climate is temperate Mediterranean, with hot and dry summers. During the 2023 growing season, the mean annual temperature was 13.7 °C and the accumulated precipitation was 1209 mm. Both the mean annual temperature and accumulated precipitation data for this period were obtained from the weather station located at INIA Santa Rosa, Chillán (36° 32' S latitude, 71° 54' W longitude and 195 m.a.s.I.) (INIA, 2023). Orchard radiation was quantified using an AccuPAR LP-80 ceptometer (Decagon Devices Inc., Washington, DC, USA). Measurements of photosynthetically active radiation (PAR) were taken at four time points throughout the day. The results indicated a gradual increase from 670 µmol $m^{-2}$ $s^{-1}$ at 09:00 h to 1620 µmol $m^{-2}$ $s^{-1}$ at 12:00 h, reaching a peak of 1820 µmol $m^{-2}$ $s^{-1}$ at 15:00 h before declining to 1050 µmol $m^{-2}$ $s^{-1}$ at 18:00 h.

At the beginning of the study, a soil analysis was conducted at a depth of 0–30 cm in the laboratory of the Universidad de Concepción. Soil organic matter (OM) was determined using the method of Sadzawka *et al*. (2006). Available nitrogen, phosphorus, and potassium (N, P, and K) were measured using the method described by Watanabe and Olsen (1965). Soil pH was measured in water at a ratio of 1:5 (v/v). The results of this analysis were as follows: available nitrogen was 83.7 mg $kg^{-1}$, Olsen phosphorus was 19.1 mg $kg^{-1}$, and available potassium reached 278.7 mg $kg^{-1}$. In addition, the soil had an organic matter content of 10.2%, and the pH was 5.9, indicating moderately acidic conditions.

### *Experimental design*

The statistical design used was a randomized complete block design with four treatments and four replicates (n = 16). Four treatments were established in 2022: a no-mulch control (T1), pine residue chipping mulch (T2), oat stubble mulch (T3), and geotextile mulch (T4). The organic mulches (oat stubble and pine residue chipping) were applied to the soil at a thickness of 20 cm, corresponding to 0.068 g $cm^{-3}$ for oat stubble and 0.134 g $cm^{-3}$ for pine residue chipping. The geotextile mulch consisted of black polypropylene with 98% light exclusion and a thickness of 100 µm.

***Orchard establishment***

The *Ugni molinae* Turcz plants used for orchard establishment were acquired from the La Huella nursery, located in the city of Valdivia, Los Ríos Region, Chile, in 2022 (39° 46' S latitude, 73° 14' W longitude and 15 m.a.s.l.). The plants were distributed with a spacing of 1 m within rows and 3 m between rows, with a planting density of 3,333 plants ha$^{-1,}$ based on the recommended density for blueberry cultivation due to the similarity in growing conditions (Undurraga *et al*., 2013). The total experimental area was 360 m2 with 64 plants in total, distributed in 16 rows of 20 m each.

***Physiological measures***

Physiological measurements were taken four times per day: 09:00 h, 12:00 h, 15:00 h, and 18:00 h on a sunny day, using the central part of a mature shoot as the reference point. Photosystem II maximum quantum yield (Fv/Fm) and stomatal conductance (gs, mmol m-2 s-1) were measured with a portable OS-5p fluorometer (Opti-Sciences, Hudson, NH, USA), after dark adapting leaves for 30 min, and with a portable porometer model SC-1 (Decagon Devices, Washington, DC, USA), respectively (Maxwell & Johnson, 2000; Retamal-Salgado *et al*., 2017). Chlorophyll content in leaves was determined by SPAD units, using the Minolta SPAD-502DL Plus (Konica minolta, INC, Osaka, Japan).

***Weeds, mulch temperature, and murta leaves***

The dry weight of the weeds was determined by weighing the collected samples growing within 1 m² of each plant. The weeds were subsequently dried in a BOV-VF Series forced air oven (BIOBASE, Jinan, China) at 105 °C for 72 h. Leaf and mulch surface temperature (°C) was determined using a portable infrared thermometer CTR1000 (Instrumentos WIKA S.A.U., Barcelona, Spain) at four times of the day (09:00, 12:00, 15:00, and 18:00 h).

***Height of plant, height of stems, and number of stems***

For the measurement of plant height and stem height, an Ubermann 6" BT RM813 measuring tape was used. The total height of each plant was determined by measuring from the base of the main stem, at ground level, to the apex of the plant. For the measurement of stem height, all stems present on the plant were considered, recording the distance from their insertion point at the base to their upper end.

To determine the number of stems per plant, each stem present at the base of the plant was counted. The procedure consisted of individually identifying and recording the stems of all the plants in the treatments from the point of insertion in the soil.

***Statistical analysis***

The results of the treatments in this study were compared using a one-way analysis of variance (ANOVA). For the comparison of means, Fisher's Least Significant Difference (LSD) test was used at a significance level of 0.05. INFOSTAT software version 2020 was used to perform both statistical tests. All figures and tables were generated using Excel 2019 and RStudio 4.2.1 software (Kahle & Wickham, 2013). A Principal Component Analysis (PCA) biplot together with a correlogram of Pearson's correlation coefficients was used to explore the relationships between the measured variables.

## RESULTS

***Physiological parameters***

In the maximum quantum efficiency of photosystem II (Fv/Fm) (Figure 1A), significant differences were observed at 09:00 and 15:00 h ($p$ < 0.05). At 09:00 h, the geotextile treatment showed a significantly higher value compared to the oat treatment, representing an increase of 21.7%. At 15:00 h, the pine treatment showed a significantly lower value than the control, corresponding to a decrease of 18.7%. However, at 12:00 and 18:00 h, no significant differences between treatments were observed. At 12:00 h, the mean values were: control 0.609, pine 0.637, oats 0.613, and geotextile 0.657. At 18:00 h, the averages ranged from 0.544 (control) to 0.647 (oats). On the other hand, when evaluating stomatal conductance (Figure 1B) and chlorophyll index (SPAD) (Figure 1C), no statistically significant differences were found between treatments at any of the times evaluated ($p < 0.05$).

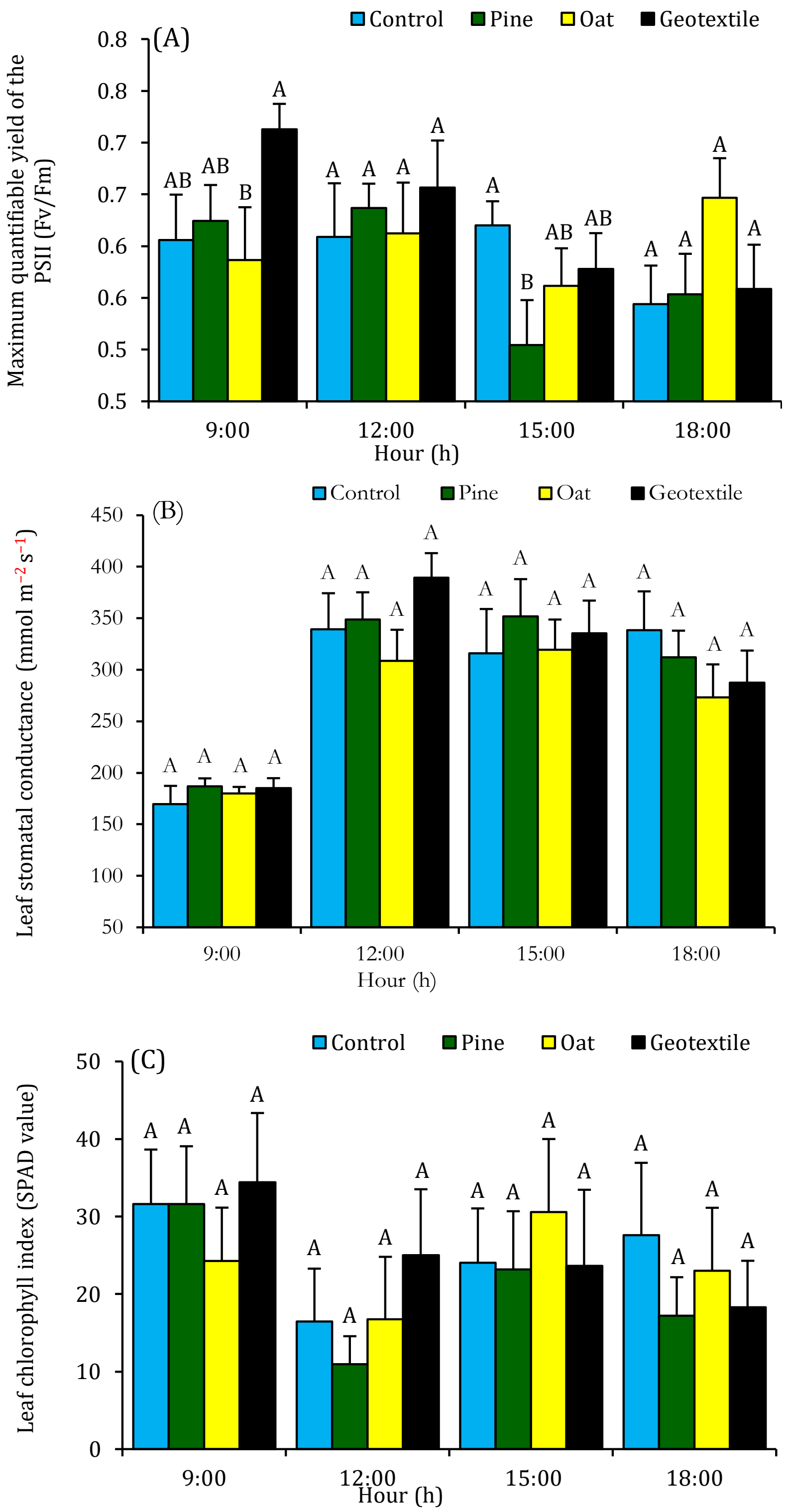



**Figure 1.** *Physiological responses of murta plants at different times of the day*

(A) Maximum quantum yield of photosystem II (Fv/Fm); (B) Leaf stomatal conductance (mmol $m^{-2}$ $s^{-1}$); (C) Chlorophyll index. Measurements were taken at 09:00 h, 12:00 h, 15:00 h, and 18:00 h. Treatments: Control (no mulch), Pine (pine residue chipping), Oats (oat stubble) and Geotextile (geotextile mulch). Capital letters indicate significant statistical differences between treatments according to the LSD Fisher test Change by ( $p < 0.05$).

***Weeds***

The number of weed species (Table 1) identified varied across treatments. In the control treatment, 8 different species were recorded, while 5 species were identified in the pine treatment. The oat and geotextile treatments each presented 2 species.

The most frequently recurring species were *Solanum nigrum*, found in 3 treatments (control, pine, and oat), and *Cestrum parqui,* which appeared in both the control and pine treatments. *Echinochloa crus-galli* and *Portulaca oleracea* were also found in control and pine treatments. *Poa annua* was common to both oat and geotextile treatments. Statistically significant differences were observed in total weed biomass among treatments (Figure 2). The geotextile treatment drastically reduced weed biomass, achieving a 98.97% reduction compared to the control, 98.61% relative to the oat mulch, and 97.82% compared with the pine treatment.

**Table 1.** *Weed species identified under different mulch treatments in the experimental orchard*

| Control | Pine | Oat | Geotextile |
|---|---|---|---|
| *Cestrum parqui* | *Cestrum parqui* | *Poa annua* | *Poa annua* |
| *Chenopodium album* | *Datura ferox* | *Solanum nigrum* | |
| *Convolvulus arvensis* | *Echinochloa crus-galli* | | |
| *Datura ferox* | *Portulaca oleracea* | | |
| *Echinochloa crus-galli* | *Solanum nigrum* | | |
| *Portulaca oleracea* | | | |
| *Raphanus sativus* | | | |
| *Solanum nigrum* | | | |

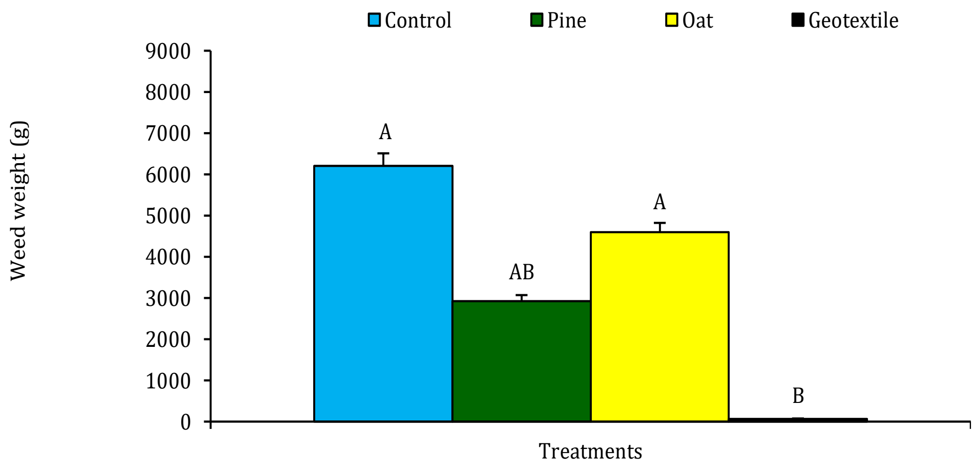
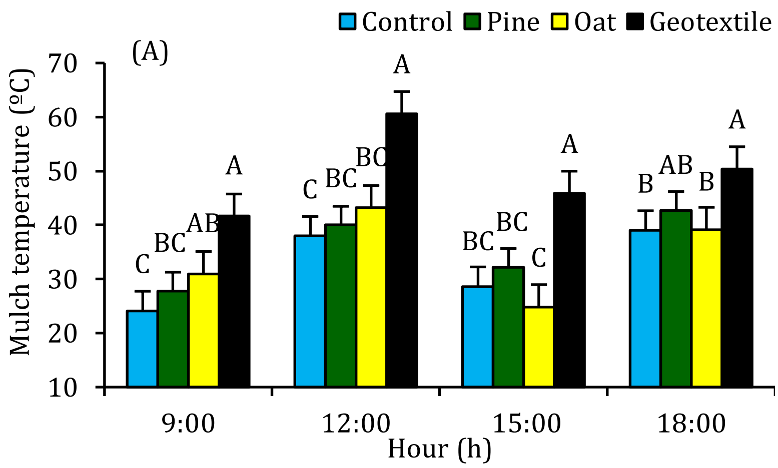



**Figure 2.** *Dry weight of weeds under different mulch treatments*

Treatments: Control (no mulch), Pine (pine residue chipping), Oats (oat stubble), and Geotextile (geotextile mulch). Capital letters indicate significant statistical differences among treatments according to the LSD Fisher test Change by ($p < 0.05$).

### *Mulch and Leaf temperature*

In terms of geotextile temperatures (Figure 3A), geotextile treatment is distinguished by maintaining significantly higher temperatures than the others throughout the day. At 12:00 h and 18:00 h, it exceeded 50°C, representing an increase of 38% and 25.5%, respectively, compared to the control treatment. On the other hand, the oat treatment showed a significantly lower temperature at 15:00 h, being 13.8% lower than the control, suggesting a possible moderating effect of temperature. Regarding leaf temperature (Figure 3B), no statistically significant differences were observed between treatments at any of the evaluated time points ($p > 0.05$). At 09:00 h, average values ranged from 25.2 °C (geotextile) to 25.8 °C (control and oat). At 12:00 h, temperatures ranged from 30.4 °C (control) to 31.1 °C (pine). At 15:00 h, averages varied between 34.5 °C (oat and geotextile) and 35.1 °C (pine). At 18:00 h, values ranged from 35.5 °C (control and oat) to 36.2 °C (pine and geotextile).



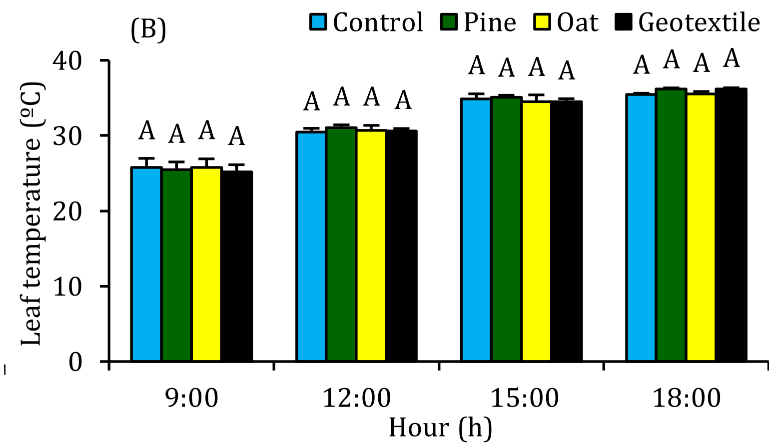




**Figure 3.** *Mulch surface temperature (A) and leaf temperature (B) at four times of the day*

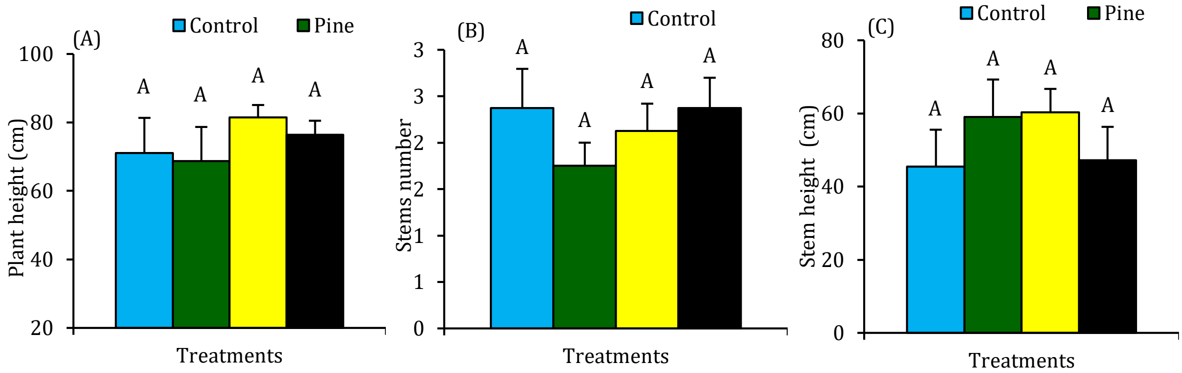
Measurements were taken at 09:00 h, 12:00 h, 15:00 h, and 18:00 h. Treatments: Control (no mulch), Pine (pine residue chipping), Oats (oat stubble) and Geotextile (geotextile mulch). Capital letters indicate significant statistical differences among treatments according to the LSD Fisher test *($p < 0.05$)*.

***Morphological parameters***

For plant height (Figure 4A), no statistically significant differences were observed among treatments ($p > 0.05$). The highest average value was recorded in the oat treatment (81.5 cm), followed by the geotextile (76.4 cm), control (71.1 cm), and pine (68.8 cm) treatments.

For the number of stems (Figure 4B), no statistically significant differences were observed among treatments ($p > 0.05$). The recorded average values were control 2.4; geotextile 2.4; oat 2.1; and pine 1.8 stems per plant.

For stem height (Figure 4C), no statistically significant differences were observed among treatments ($p > 0.05$). The highest average value was recorded in the oat treatment (60.3 cm), followed by the pine (59.1 cm), geotextile (47.3 cm), and control (45.5 cm) treatments.




*Note.* (A) Plant height, (B) stem number, and (C) stem height. Treatments: Control (no mulch), Pine (pine residue chipping), Oats (oat stubble), and Geotextile (geotextile mulch). Capital letters indicate significant statistical differences among treatments according to the LSD Fisher test *($p < 0.05$)*.

**Figure 4**. *Morphological parameters of murta plants under different mulch treatments*

**Soil moisture.** Statistically significant differences in soil moisture (Figure 5) were observed on 15 February and 2 March ($p < 0.05$). On 15 February, the geotextile treatment recorded a significantly higher value than the control, with an increase of 12.5%. Similarly, on 2 March, the geotextile outperformed the control by 14.8%. However, no significant differences were observed between the treatments on 1 February and 17 March. On 1 February, mean values ranged from 40.7% (oats) to 43.1% (geotextile). On 17 March, values ranged from 41.7% (geotextile) to 47.0% (control).

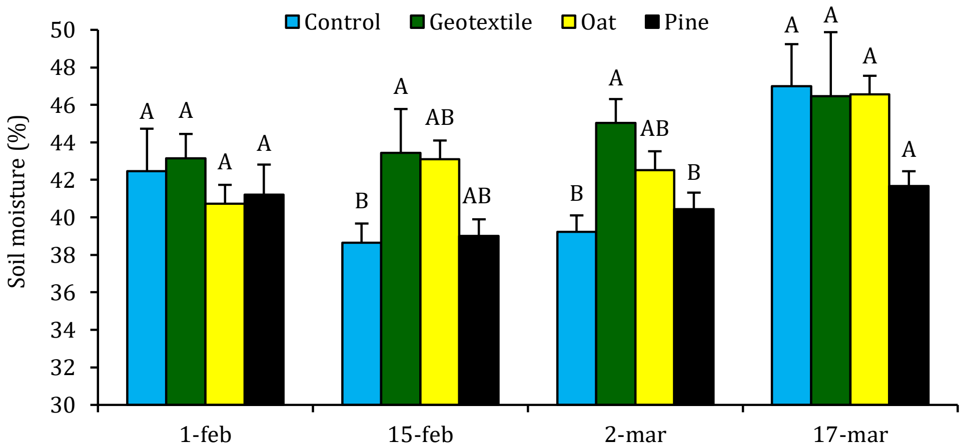



**Figure 5.** *Soil moisture under different mulch treatments*

Measurements are expressed as percentage (%). Treatments: Control (no mulch), Pine (pine residue chipping), Oats (oat stubble), and Geotextile (geotextile mulch). Capital letters indicate significant statistical differences among treatments according to the LSD Fisher test *($p < 0.05$).*

### *Correlations*

The biplot of the principal component analysis (Figure 6A) shows that the first two axes explain 32.3% and 21.1% of the total variance, respectively. Mulch temperature and PAR radiation were among the most influential variables along principal component 1 (Dim1), showing a strong directional pull and high contribution values. Growth-related traits such as plant height, stem height, and stem count contributed strongly along principal component 2 (Dim2).

The correlogram presents Pearson correlation coefficients (Figure 6B) among all measured variables. The size and color intensity of the circles indicate the strength and direction of each correlation, with red representing positive and blue negative relationships. Notably, mulch temperature showed a strong negative correlation with weed biomass ($r = –0.72$). SPAD values (chlorophyll index) were positively correlated with stem count ($r = 0.67$) and plant height ($r = 0.57$). Meanwhile, soil moisture was positively associated with fluorimeter readings ($r = 0.62$), suggesting improved photosystem efficiency under higher water availability.

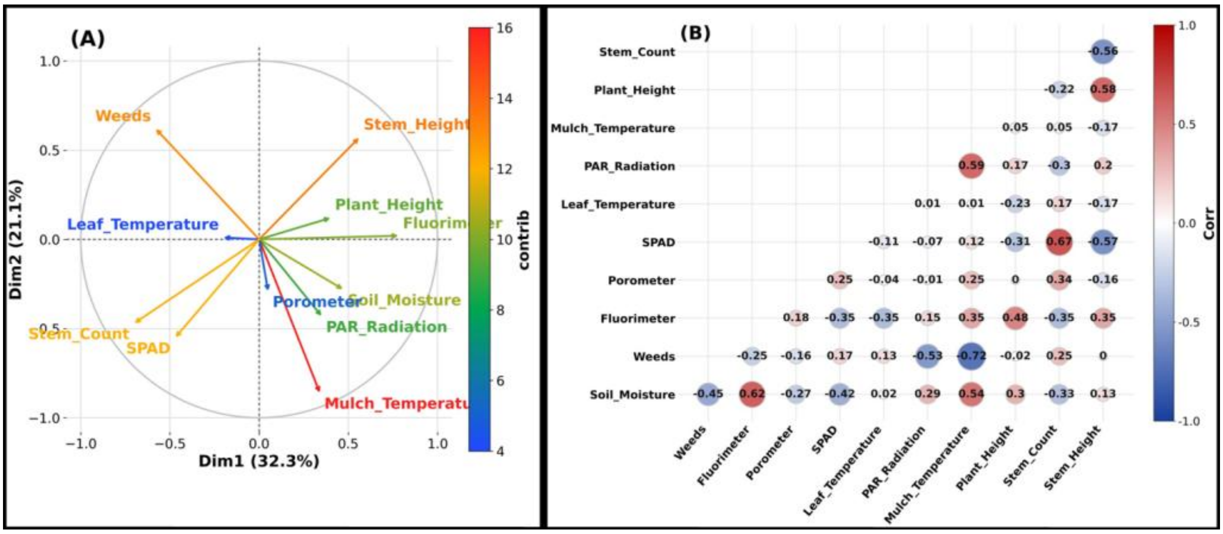



**Figure 6.** *Multivariate analysis of physiological and morphological variables in murta plants*

(A) Biplot of Principal Component Analysis (PCA); (B) correlogram of Pearson correlation coefficients among the measured variables.

## DISCUSSION

### *Physiological parameters*

The maximum quantum yield of photosystem II (Fv/Fm) was higher in the morning (09:00 h), particularly under geotextile mulching, which is due to its function as a soil thermal regulator, resulting in improved photosynthetic efficiency (Jia *et al*., 2023). This effect, also observed in heat-sensitive crops such as tomatoes (Camejo *et al*., 2005), could be due to the combination of higher temperatures and greater radiation in the mornings. It should be noted that the geotextile maintained higher soil moisture, which improves nutrient solubility (Jia *et al*., 2023) and promotes the nutrient release through the decomposition of organic matter (Guntiñas *et al*., 2012; Accoe *et al*., 2005). In contrast, the pine mulch treatment had the lowest Fv/Fm values in the afternoon (15:00), possibly due to soil acidification, which led to plant stress, negatively affecting photosynthesis (Bhuyan *et al*., 2019). The decline in Fv/Fm observed in the pine mulch treatment during the afternoon (15:00 h) warrants further consideration. Pine residues are characterized by a high lignocellulosic content and the presence of tannins and phenolic acids, which upon decomposition can release organic acids into the soil, gradually reducing soil pH (Bhuyan *et al*., 2019; Paramashivam *et al*., 2016). Although the experimental period of this study (three months) may not have been sufficient to produce a significant change in bulk soil pH, localized acidification near the rhizosphere cannot be ruled out. Such conditions can impair the availability of key nutrients such as phosphorus, calcium, and magnesium, potentially affecting the integrity of the photosynthetic apparatus (Bhuyan *et al*., 2019). Additionally, pine mulch showed intermediate soil moisture values, neither as high as geotextile nor as variable as the control, suggesting that transient water deficit during peak radiation hours could have contributed to stomatal limitations and a consequent reduction in photosystem II efficiency in the afternoon (Hu *et al*., 2023; Sperdouli *et al*., 2021).

Future studies should include direct soil pH measurements under each mulch type at different time points to better disentangle the relative contributions of rhizosphere acidification and punctual water stress to the observed Fv/Fm response. The absence of significant differences in stomatal conductance could be due to characteristics of the species itself or to high soil fertility, which minimizes the effects of the treatments (Lin *et al*., 2015; Tardieu *et al*., 1991).

Stable soil moisture can also reduce osmotic stress and improve gas exchange, promoting photosynthesis and interactions between roots and soil microorganisms (Rawson *et al*., 1976; de la Porte *et al*., 2020; Kuhad *et al*., 2011). The SPAD index showed no significant differences between treatments, which is consistent with studies indicating that chlorophyll content remains stable under moderate environmental variations (Shah *et al*., 2017). On the other hand, the positive correlation between the SPAD index and plant growth ($r = 0.67$ for number of stems; $r = 0.57$ for height) is supported by previous research, such as Vishwakarma *et al*. (2023), which demonstrated that higher SPAD index values are related to higher chlorophyll content and, therefore, more vigorous growth in different species.

The positive correlation between soil moisture and Fv/Fm values ($r = 0.62$) also coincides with studies showing a reduction in photosystem II efficiency under drought conditions (Hu *et al*., 2023; Sperdouli *et al*., 2021). However, the changes induced by the different mulches may not have been intense or prolonged enough to significantly affect the synthesis or degradation of chlorophyll present in *Ugni molinae* Turcz plants.

***Morphological parameters***

The different types of mulching did not produce statistically significant differences in the morphological parameters of murta (plant height, number of branches, and branch length) among treatments. Although the mulches demonstrated improved soil moisture retention (as evidenced in this study), they could also enhance nutrient availability, especially in the case of organic mulches (Burkhard *et al*., 2009). Furthermore, it is important to note that the murta plant may develop under adverse conditions, as is the case with other native species such as calafate (Radice *et al*., 2018), and the Andisol soils in this study, characterized by high organic matter content (Dahlgren *et al*., 2004), could meet the plant's requirements.

Unlike the results of the present study, other studies have shown that the incorporation of straw residue improves soil properties, as the organic acids released during its decomposition solubilize part of the inorganic phosphorus present, making it available for plant uptake (Wang *et al*., 2020; Gaitanis *et al*., 2023). However, in contrast to previous studies, the present experiment had a shorter mulching period (3 months), which could explain this difference, given that there might not have been sufficient time for decomposition and incorporation (Valenzuela-Solano & Crohn, 2006).

***Weed content***

The mulches were effective in controlling weeds. These findings align with the observations made by Frutos *et al*. (2016) and Agarwal *et al*. (2022), who highlighted the capacity of mulches to inhibit weed growth by blocking light penetration. Additionally, plastic mulches, such as black polyethylene, can increase soil temperature, contributing to a reduction in weed emergence (Ibarra-Jiménez *et al*., 2008). Although this study did not focus on exhaustive taxonomic identification of species, it is relevant to consider findings from similar research. For instance, studies conducted in fruit and vegetable production systems in southern Chile frequently reported the presence of species such as *Solanum nigrum*, *Echinochloa crus-galli*, and *Portulaca oleracea* (Tei *et al*., 2003; Fuentes *et al*., 2008), which were also recorded in the present trial.

Among the species identified in this study, *Echinochloa crus-galli* stands out as a weed difficult to manage. This species can form persistent seed banks and regenerate from rhizomes, complicating its control even under mulching conditions (Bajwa *et al*., 2015). Recent studies have demonstrated that this species can adapt to various cover types, even penetrating lightweight materials and developing in low-light microenvironments, thereby limiting the effectiveness of certain organic mulches (Bajwa *et al*., 2015). *Echinochloa crus-galli* and *Solanum nigrum*, present in all treatments except geotextile, stand out for their ability to develop under partial cover conditions, suggesting high shade tolerance and superior physiological efficiency (Royo-Esnal *et al*., 2022; Bajwa *et al*., 2015; Stotz *et al*., 2025).

Furthermore, the recurrent presence of *Portulaca oleracea* in treatments without effective cover indicates a high adaptation capacity to thermal stress and low moisture conditions (Ferrari *et al*., 2020; Feng *et al*., 2015). Similarly, *Solanum nigrum*, a fast-growing annual weed, exhibits high reproduction rates and efficient water use, factors that contribute to its dominance under competitive conditions (Caussanel *et al*., 1990).

The results indicate that geotextile treatment significantly enhanced soil moisture conservation during specific observation periods. Statistically, it increased moisture over the control. These findings align with prior studies demonstrating the capacity of organic and synthetic mulches to improve soil water retention (Stelli *et al*., 2018; Corradini, 2014; Yang *et al*., 2018; Saputra *et al*., 2025). This variability highlights that mulch effectiveness is influenced by multiple factors such as material type, soil characteristics, climate, irrigation, and antecedent soil moisture (Yang *et al*., 2018).

***Mulch temperature***

Mulch temperature increased significantly under the geotextile treatment, due to the black synthetic material's ability to absorb solar radiation, creating a surface thermal gradient (Derbala & Darwesh, 2013). Rather than indicating thermal-hydric stability, the high surface temperatures recorded under geotextile suggest a strong warming effect of this material, which may have contributed to weed suppression but should not be interpreted as inherently beneficial for soil conditions (Bandopadhyay *et al*., 2018). Since soil biodiversity and biological processes were not directly evaluated in the present study, the potential ecological implications of these high temperatures should be considered in future research. Greater soil moisture under geotextile may have supported nutrient availability and microbial activity, key factors in volcanic soils (Radulov & Berbecea, 2024; Dahlgren *et al*., 2004). Studies suggest that such environments promote beneficial microbes and nutrient cycling (Bauke *et al*., 2022; Vargas *et al*., 2021). Conversely, pine mulch may limit nitrogen availability due to its lignocellulosic content (Paramashivam *et al*., 2016). The control showed the lowest moisture, greater thermal variability, and potential compaction conditions, reflected in poorer plant performance (Appleton *et al*., 1990).

These findings align with Maurya *et al*. (2020), who reported that synthetic mulches enhance moisture retention and water use in tomato crops. However, the impact of the high surface temperatures recorded under geotextile on soil biological conditions was not assessed in the present study. Higher mulch temperatures were correlated with fewer weeds, consistent with Iqbal *et al*. (2020) and Ramakrishna *et al*. (2006), who found that elevated mulch temperatures inhibit weed germination by altering the soil microclimate.

***Future prospects of the study***

The present study contributes to the evaluation of feasible weed management practices through the use of mulch to improve plant efficiency in the cultivation of new native species as an emerging productive alternative. However, since this study was not effective in detecting certain plant changes observed in other research, future studies could consider variables not included here, such as different types of agricultural residue mulches, for example, from grapevine, hazelnut, and others (Burg *et al*., 2022; Matišić *et al*., 2023). In addition, the experimental period should be extended beyond that of this study (3 months) to observe medium- and long-term effects, as evidenced in previous research (DeVincentis *et al*., 2022; Wang *et al*., 2015). Soil variables such as microbial communities and nutrient cycling should also be considered, as these are vital indicators of soil status and health. Furthermore, it is important to assess fruit quality parameters in mature orchards to determine the impact of mulch on yield and antioxidant traits, as has been done in species like calafate (Betancur *et al*., 2023).

## CONCLUSIONS

The findings of this study confirm that mulch type is related to the physiological performance, weed suppression, and soil moisture dynamics of *Ugni molinae* Turcz. Among the treatments evaluated, geotextile mulch stood out by significantly reducing weed biomass by over 97%, maintaining higher soil moisture on key dates, and improving Fv/Fm values, indicating enhanced photosynthetic efficiency. Although no significant differences were observed in morphological variables, multivariate analyses revealed strong correlations between mulch surface temperature, moisture content, and physiological responses, particularly under the geotextile treatment. These results support the potential of mulching as a feasible weed management strategy in murta cultivation. While geotextile showed the most consistent performance, its use should be further evaluated considering long-term agronomic and ecological impacts, particularly in relation to soil biodiversity, material persistence, and integrated management in native berry systems. Future studies should evaluate these materials over extended timeframes and include fruit production and quality variables to better understand their suitability for integrated native crop systems.

## AUTHOR CONTRIBUTIONS

Conceptualization, M.B., A.P.-P., and J.L.; Methodology, M.V.-G., M.B., A.P.-P., J.L., Y.R.-T., F.P.-M., and S.M.B.; Software, M.B., A.P.-P., J.L., and S.M.B.; Validation, M.B., A.P.-P., J.L., Y.R.-T., F.P.-M., and S.M.B.; Formal Analysis, M.V.-G., M.B., A.P.-P., J.L., Y.R.-T., F.P.-M., and S.M.B.; Investigation, M.V.-G., M.B., A.P.-P., J.L., Y.R.-T., F.P.-M., and S.M.B.; Resources, A.P.-P.; Data Curation, M.V.-G., A.P.-P., Y.R.-T., F.P.-M., and S.M.B.; WritingOriginal Draft Preparation, M.V.-G., M.B., A.P.-P., Y.R.-T., F.P.-M., and S.M.B.; WritingReview & Editing, M.B., A.P.-P., Y.R.-T., F.P.-M., and S.M.B.; Project Administration, A.P.-P.; Funding Acquisition, A.P.-P.

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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