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# The Influence of Mycorrhiza Application and Watering Intervals Under Drough Conditions on Vegetative Growth of Soybean (*Glycine Max* L. Merril.)

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**Abstract.** Drought or dry season is an abiotic factor related to low availability of groundwater, which causes impaired plant growth. Water deficiency in plants will disrupt morphological and physiological activities, leading to halted growth. Mycorrhiza is a beneficial microorganism and a harmless symbiotic fungus that provides mutual benefits between soil-transmitted fungi and plant roots, helping in water and nutrient absorption. This study aims to determine the effect of mycorrhiza and the optimal watering level in overcoming drought stress in soybean plants (*Glycine max* L. Merril.). This study used a factorial Randomized Block Design consisting of 2 treatment factors with 3 replications. The first factor was mycorrhizal dosage with treatments M0 (0 g), M1 (15 g), M2 (25 g), M3 (35 g), and the second factor was the watering interval with treatments P0 (no watering), P1 (1 day), P2 (3 days), P3 (5 days). The study was conducted from January to February 2025. The results showed that the application of mycorrhiza at a dose of 15 g can increase the average root volume. Meanwhile, a mycorrhiza dose of 35 g can increase the average stomatal density, root dry weight, shoot dry weight, and the number of leaves. Meanwhile, the best watering treatment was P1 (once a day), which was able to increase the average leaf number parameter. Treatment P2 (once every 3 days) was able to increase the average parameters of stomatal density and shoot dry weight. Treatment P3 (once every 5 days) was able to increase the average parameters of root dry weight and shoot dry weight. The interaction of a 15 g mycorrhiza dose and a 1-day watering interval showed the highest averages in leaf number parameters. Meanwhile, the interaction of a 35 g mycorrhiza dose and a 3-day watering interval was increase the average in the stomatal density parameter. The interaction of a 35 g mycorrhiza dose and a 5-day watering interval was able to increase the average in, root dry weight, and shoot dry weight parameters.

**Keywords:** Soybean; Drought; Watering Interval; Mycorrhiza.



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## INTRODUCTION

Soybeans (*Glycine max* L. Merrill.) are a major source of plant protein, a raw material for the food industry, animal feed, and various processed products, and soybeans are considered a strategic food commodity in Indonesia. In addition, soybeans are legumes that are high in fat, carbohydrates, and plant protein. Besides having a complete amino acid composition, soybean seeds also contain calcium, iron, phosphorus, and vitamin B (Fauzi & Dewi, 2018). Every year the demand for soybeans continues to increase. The amount of soybeans produced nationally has varied in recent years. Data Badan Standardisasi Alat Pertanian (BSIP) shows that soybean production sharply declined to only 212,850 tons in 2021 from 3.29 million tons in 2020. As of December 2023, domestic soybean production was around 555,000 tons, while national demand reached 2.7 million tons, according to BPS statistics (BSIP, 2023). Over the past five years, the average amount of dried soybeans produced domestically has been only 982,470 tons, or about 43% of total demand. As a result, there has been a production shortfall that ultimately has to be met through imports (Balitkabi, 2018)

One of the many causes of the decline in Indonesia's soybean production is climate change due to global warming, which has significant impacts on various aspects of life, including the agricultural sector, particularly the food crop subsector that is vulnerable to climate change. Drought is an abiotic condition related to the reduced availability of groundwater. Plants under this condition experience stress, which can result in biological stress affecting physiological functions and functional activities. Soybean yields decrease significantly due to drought stress during the vegetative period; water stress causes smaller leaves, narrower stem diameters, slower plant development, and lower total plant weight. The reduction in plant cell turgor pressure is a direct effect of drought stress, but many physiological activities, including photosynthesis, nitrogen metabolism, nutrient absorption, and the translocation of photosynthetic products, may be indirectly affected. The use of biofertilizers, such as mycorrhiza, can improve the efficiency of water and nutrient uptake as well as enhance plant growth during drought conditions, which is one way to mitigate the impact of drought stress on soybean agriculture (Suryaningrum & Sumiyati, 2016).

Mycorrhiza is a symbiotic fungus that is harmless and is one of the beneficial microorganisms. Mycorrhiza even helps plant roots absorb nutrients by working together with soil fungi. Mycorrhizal fungi not only aid nutrient absorption in plants, especially phosphate, but also enhance their resistance to diseases, drought, and salt stress (Ruíz-sánchez et al., 2011). Mycorrhiza can help soybean plants absorb more nutrients, as well as provide immunity and drought resistance to their host plants, making it harder for diseases to enter the roots (Suherman et al., 2012).

(Fahmissidqi, 2016) reported in previous research that the application of mycorrhiza at a dose of 7.5 g/polybag had a significant effect on the root length and root infection rate of soybean plants. Mycorrhizal biofertilizer at a dose of 22 g/polybag had a significant effect on the 100-seed weight of the Grobogan variety, which weighed 23.97 g, according to another study by (Isnaini et al., 2022). In his research, (Yunedi & Andrian Perdana, 2023) found that mycorrhiza at doses of 30 g and 15 g per plant could increase total growth variables and soybean plant production compared to plants not treated with mycorrhiza. For plants to grow and develop, water is an essential component. Water deficiency can cause morphological and physiological changes in plants, which will ultimately halt their growth. In general, watering treatment with a frequency of once a day results in higher fresh root weight compared to watering every three days. The low fresh root weight with watering every three days is suspected to be caused by limited water availability for the plants. Additionally, (Muis & Widada, 2013) found that watering once every six days can reduce soil water content, inhibit root and shoot growth, and decrease plant production and total dry weight. This is in line with the research of (Sarawa et al., 2014), who found that the longer the interval between watering, the less water is available in the soil, which leads to the production of growth-inhibiting hormones.

## MATERIALS AND METHODS

The research was conducted from January to February 2025 at the Greenhouse and Botanical Laboratory of the Universitas Islam Negeri Sumatera Utara, Lapangan Golf Street, Durin Jangak Village, Pancur Batu District, Deli Serdang Regency. The equipment used in this study included polybags, clear plastic, analytical balance, meter, oven, microscope slides, cover glass, measuring cup, cutter knife, dropper pipette, microscope, tweezers, UV plastic, label paper, digital camera, hammer, clear nail polish, bamboo, hoe, plastic rope, envelope paper, and stationery. Meanwhile, the materials used in this study were Anjasmoro soybean seeds, mycorrhizal fungi, water, topsoil, NPK fertilizer, and insecticide. This study used a factorial Randomized Block Design consisting of 2 treatment factors with 3 replications, factor 1 consist of mycorrhizal dose with 4 treatment levels, namely (0 g, 15 g, 25 g, and 35 g) of mycorrhiza. Factor 2 consist of watering interval, with 4 treatment levels, namely (control without watering, once a day, once every 3 days, and once every 5 days).

The steps taken in this research are in the form of, starting with the construction of a plastic shelter measuring 9x7 meters with a height of 2 meters, preparation of planting media using topsoil which was dried and ground/sifted beforehand to obtain fine soil, application of mycorrhiza twice: first on the seeds by coating the seeds with mycorrhiza, then by aplicate mycorrhiza around the plant roots, planting soybean seeds at a hole depth of approximately 2 cm with 2 seeds per polybag, watering and maintaining the soybean seedlings, and observation parameters such as the shoot dry weight, number of leaves, root dry weight, and stomatal density.

The number of leaves is counted once a week at 2, 3, 4, 5, and 6 WAP. Measurement of root dry weight and shoot dry weight is carried out at the end of the vegetative phase (6 WAP) after that, the plants are taken out of the oven, and the shoots or roots are weighed using an analytical balance. To observe stomatal density on soybean leaves using replicas or impressions, the leaves to be observed are coated with nail polish, and then the nail polish is carefully peeled off. The nail polish print is then placed on the microscope slide, and clear tape is applied to the print to prevent it from shifting. The number of stomata in each field of view is counted using a microscope at 40x magnification. The area of the field of view is calculated using a formula based on research (Lestari, 2006).

$A = ¼ \pi d^2$

$A = ¼ \times 3.14 \times 0.5^2$

$A = 0.19625 \text{ mm}^2$

$$Stomatal\ Density = \frac{Number\ of\ stomata}{Area\ of\ the\ field\ of\ view}$$

The analysis obtained from quantitative measurements and stomatal density was then analyzed using *analysis of variance* (ANOVA). If there is a significant difference ($P<0.05$) in the data, it is followed by the *Duncan Multiple Range Test* (DMRT).

## RESULTS AND DISCUSSION

Based on research conducted on the effect of mycorrhiza application and watering intervals under drought conditions on the vegetative growth of soybean (*Glycine max* L. Merril.), the following results were obtained:

### Number of Leaves

The results of the ANOVA test that has been conducted show that the treatment of mycorrhiza application, watering interval, and the combination of mycorrhiza treatment and watering interval have a significant effect on the leaf number parameter at 5 and 6 WAP. The significant effect of mycorrhiza application, watering interval, and the combination of mycorrhiza treatment and watering interval on the number of soybean leaves at 5 and 6 WAP can be seen in Table 1.

**Table 1.** Average Number of Soybean Leaves at 5 and 6 WAP.

| Watering | | Mycorrhiza | | | | Average |
|---|---|---|---|---|---|---|
| | | M0 (0 g) | M1 (15 g) | M2 (25 g) | M3 (35 g) | |
| 5 WAP | P0 (0 Day) | 23.00$^{f}$ | 23.00$^{f}$ | 25.00$^{de}$ | 25.66$^{c-e}$ | 24.41$^{d}$ |
| | P1 (1 Day) | 21.33$^{g}$ | 30.66$^{a}$ | 29.00$^{b}$ | 27.00$^{c}$ | 27.00$^{a}$ |
| | P2 (3 Days) | 25.66$^{c-e}$ | 25.66$^{cd}$ | 26.00$^{cd}$ | 23.33$^{f}$ | 25.16$^{c}$ |
| | P3 (5 Days) | 24.33$^{ef}$ | 24.33$^{ef}$ | 27.00$^{c}$ | 29.33$^{ab}$ | 26.25$^{b}$ |
| Average | | 23.58$^{c}$ | 25.91$^{b}$ | 26.75$^{a}$ | 26.33$^{ab}$ | |
| 6 WAP | P0 (0 Day) | 28.00$^{hi}$ | 28.33$^{g-i}$ | 29.66$^{e-h}$ | 31.00$^{c-f}$ | 29.25$^{c}$ |
| | P1 (1 Day) | 26.66$^{i}$ | 36.66$^{a}$ | 35.00$^{ab}$ | 32.66$^{bc}$ | 32.75$^{a}$ |
| | P2 (3 Days) | 30.66$^{c-g}$ | 31.33$^{c-f}$ | 32.00$^{c-e}$ | 28.00$^{hi}$ | 30.50$^{b}$ |
| | P3 (5 Days) | 29.00$^{f-i}$ | 30.00$^{d-h}$ | 32.33$^{cd}$ | 35.00$^{ab}$ | 31.58$^{b}$ |
| Average | | 28.41$^{b}$ | 31.58$^{a}$ | 32.25$^{a}$ | 31.66$^{a}$ | |

Based on Table 1, the average number of leaves was highest for the mycorrhizal treatment at 5 WAP, which was in treatment M2 (25 g mycorrhiza) and not significantly different from treatment M3 (35 g mycorrhiza), while the lowest average was found in treatment M0 (0 g mycorrhiza) and was significantly different from treatments 15 g, 25 g, and 35 g. At 6 WAP, the highest average number of leaves was observed in treatment M2 with 25 g mycorrhiza and was not significantly different from treatments M1 and M3. Meanwhile, the lowest average was found in treatment M0 (0 g mycorrhiza) and was significantly different from treatments M1, M2, and M3. This indicates that the concentration range of 15-35 g of mycorrhiza has been able to enhance water and nutrient absorption and expand the root system, which improves the vegetative growth of the plant and helps produce growth hormones for leaf formation during drought. Meanwhile, in the lowest treatment (M0), it was caused by the absence of mycorrhizal hyphae that could assist plants in

increasing water and nutrient absorption as well as growth hormone production, which resulted in suboptimal metabolic activity leading to low leaf growth. In addition, after reaching a certain dose, adding mycorrhiza does not provide significant additional benefits to plant growth, so the plant's response to a dose of 25 g is not significantly different compared to doses of 15 g or 35 g. Administering mycorrhiza at the right dose can improve, support, and maintain plant growth under stressed conditions. This is shown in the study by (Ardiansyah et al., 2014), which found that mycorrhizal treatment significantly increased the number of leaves (5 WAP). This is due to improved root area health in stressed soil caused by the mycorrhiza.

The 5 WAP (weeks after planting) watering interval treatment showed the highest average number of leaves in treatment P1 with watering once a day, and it was significantly different from treatments P0, P2, and P3. Meanwhile, the lowest average was found in treatment P0 (control) without watering and was significantly different from treatments P1, P2, and P3. At 6 WAP, the highest average number of leaves was in treatment P1 (watering once a day) and was significantly different from treatments P0, P2, and P3, while the lowest average was in treatment P0 (control) and was significantly different from treatments P1, P2, and P3. This is because watering once a day ensures sufficient water availability to support the photosynthesis process in cell formation for the plants, resulting in an increase in the number of leaves under drought stress. The lowest average was found in P0 (control) due to prolonged water deficiency in the plants, which caused stress that disrupted metabolism and photosynthesis, resulting in a decrease in the production of organic cells in leaf formation. Consistent with (Sarawa et al., 2014) research, watering soybean plants at 2-day intervals produced better plant growth compared to watering at intervals of 4, 6, and 8 days, particularly in terms of leaf number. The greater the plant growth, the more water is supplied. In addition to being an essential component of cell protoplasm, water is a raw material for photosynthesis. Therefore, plant growth will be significantly hindered during water scarcity, especially during the vegetative period.

The M1P1 treatment (15 g of mycorrhizal fertilizer and 1 day of watering) had the highest average number of leaves, according to Table 1, which examines the interaction between mycorrhizal fertilizer and watering interval parameters on the number of leaves at 5 WAP. This is not significantly different from the M3P3 treatment (35 g of mycorrhizal fertilizer and 5 days of watering). The M1P1 treatment (15 g of mycorrhizal fertilizer and 1 day of watering) also had the highest average number of leaves at 6 WAP and was not significantly different from the M3P3 treatment (35 g of mycorrhizal fertilizer and 5 days of irrigation). This is because the combination of a 15 g dose of mycorrhiza with daily watering provides optimal conditions for the vegetative growth of soybean plants; at this dose, mycorrhiza is already sufficiently effective in enhancing the absorption of essential nutrients without causing saturation, while daily watering ensures soil moisture is maintained to support mycorrhizal activity and leaf formation. Meanwhile, in the M3P3 treatment, although watering was less frequent (every 5 days), the high dose of mycorrhiza (35 g) could help the plants adapt to water deficiency through the expansion of external hyphae, which increases the efficiency of soil water absorption. This resulted in a consistently high number of leaves even with infrequent watering. This aligns with the research by (Pareira et al., 2023), who found that the number of leaves in bok choy plants is significantly influenced by the application of Arbuscular Mycorrhizal Fungi (AMF). Additionally, the watering schedule has a substantial interaction effect on the number of leaves, especially when combined with AMF application. However, regular morning and evening watering schedules and treatments without AMF did not have a noticeable impact on this metric.

**Roots Dry Weight**

The results of the observation of the total leaf area of soybean (*Glycine max* L. Merril.) and the ANOVA test at 6 WAP shown in Table 2, which shows that the ANOVA test results of mycorrhizal fertilizer treatment, watering interval treatment, and the interaction of mycorrhizal fertilizer and watering interval at 6 WAP significantly affected root dry weight.

**Table 2.** Average roots dry weight of 6 WAP soybean roots

| Watering | Mycorrhiza | | | | Average |
|---|---|---|---|---|---|
| | M0 (0 g) | M1 (15 g) | M2 (25 g) | M3 (35 g) | |
| P0 (0 Day) | 0.16$^{ef}$ | 0.17$^{ef}$ | 0.07$^{j}$ | 0.26$^{c}$ | 0.16$^{b}$ |
| P1 (1 Day) | 0.15$^{f-h}$ | 0.23$^{d}$ | 0.13$^{gh}$ | 0.14$^{f-h}$ | 0.16$^{b}$ |
| P2 (3 Days) | 0.09$^{i}$ | 0.24$^{cd}$ | 0.12$^{gh}$ | 0.17$^{ef}$ | 0.15$^{b}$ |
| P3 (5 Days) | 0.12$^{hi}$ | 0.18$^{e}$ | 0.31$^{b}$ | 0.37$^{a}$ | 0.24$^{a}$ |
| Average | 0.13$^{d}$ | 0.20$^{b}$ | 0.16$^{c}$ | 0.23$^{a}$ | |

The roots dry weight due to mycorrhiza application showed that the highest value was found in treatment M3 (35 g of mycorrhiza) and shows a significantly different from treatments M0, M1, and M2. Meanwhile, the lowest was in treatment M0 (control) with 0 g of mycorrhiza and was significantly different from treatments M1, M2, and M3. This is because a high dose of mycorrhiza (M3) allows the mycorrhizal fungi to maximally infect or colonize the soybean plant roots, leading to the formation of root nodules, maintaining turgor pressure and root metabolism, therefore the dry weight of the roots increased, root length, and root volume. Meanwhile, treatment M0 with 0 g of mycorrhiza had the lowest average root volume because, without mycorrhiza, plant roots do not benefit from the hyphal colonization that expands the area for water and nutrient absorption, resulting in limited roots and small root volume, which lowers the average dry root weight. This results in limited roots and root volume, which reduces the average roots dry weight. Fresh leaf weight, fresh tuber weight, fresh root weight, and root dry weight are all influenced by mycorrhizal application, according to research by (Valentine et al., 2017).

Based on Table 2, it can be seen that the highest average root dry weight due to watering treatment occurred in treatment P3 (0.2408) and was significantly different from treatments P0, P1, and P2. Meanwhile, the lowest average was in treatment P2 and was not significantly different from treatments P0 and P1. This is because the 5-day watering treatment caused the plants to experience mild to moderate drought stress; under these conditions, the plants allocate more energy to root growth rather than the aboveground parts (canopy) as an adaptive mechanism to seek water. The 5-day stress causes the roots to tend to grow longer to penetrate deeper and expand the lateral root network, which increases root tissue mass. Meanwhile, the lowest average in treatment 3 days, which was not significantly different from treatments P0 and P1, is due to inconsistent watering frequency that can cause the plants to experience drought stress and inhibit metabolic activity, and reduces turgor pressure in root cells, thereby inhibiting root growth. According to (Parwati, 2013), watering once a day does not significantly affect seedling height, root length, fresh shoot weight, stem diameter, number of leaves, and dry root weight compared to watering every two or three days.

Table 2, we can also see that the M3P3 treatment resulted in the highest average of root dry weight and was significantly different from the other treatments. This is because mycorrhiza at a high dose can enhance hyphal colonization, thereby increasing water and nutrient absorption and stimulating hormones involved in root formation. High doses of mycorrhiza also help maintain turgor pressure and root metabolism under drought stress. Meanwhile, watering at 5-day intervals forces the plants to extend their roots and increase root biomass to access deeper water, enabling them to survive and ensure optimal water availability for plant growth. High amounts of mycorrhiza help roots improve their exploration capacity and efficiency in water and nutrient absorption under dry conditions. As a result, plants allocate more resources to root tissues, resulting in significantly higher root dry weight compared to other treatments. This is consistent with research by (Hashem et al., 2018), which showed that mycorrhizal fungal inoculation can increase drought tolerance through enhanced root morphological adaptation, accumulation of osmolytes, and water uptake.

**Shoot Dry Weight**

The ANOVA test results showed that the application of mycorrhizal fertilizer, watering interval treatments, and the combination of mycorrhizal fertilizer and watering interval treatments at 6 WAP was significant effect on the shoot dry weight parameter, as shown in Table 3.

**Table 3.** Average shoot dry weight of soybean canopy at 6 WAP

| Watering | Mycorrhiza | | | | Average |
|---|---|---|---|---|---|
| | M0 (0 g) | M1 (15 g) | M2 (25 g) | M3 (35 g) | |
| P0 (0 Day) | $3.12^{hi}$ | $4.52^{f}$ | $5.97^{de}$ | $7.70^{bc}$ | $5.33^{b}$ |
| P1 (1 Day) | $2.39^{h}$ | $7.17^{b-d}$ | $5.22^{ef}$ | $4.22^{g}$ | $4.75^{b}$ |
| P2 (3 Days) | $5.84^{de}$ | $10.65^{a}$ | $8.27^{b}$ | $6.25^{de}$ | $7.75^{a}$ |
| P3 (5 Days) | $2.73^{h}$ | $6.61^{cd}$ | $10.01^{a}$ | $10.62^{a}$ | $7.49^{a}$ |
| Average | $3.52^{b}$ | $7.24^{a}$ | $7.37^{a}$ | $7.20^{a}$ | |

It can be seen that the application of mycorrhiza at a dose of 25 g (M2) resulted in the highest average shoot dry weight (7.37) and showed no significant difference compared to treatments M1 and M3, while the lowest average shoot dry weight was found in treatment M0 and was significantly different from treatments M1, M2, and M3. This is because a mycorrhiza dose of 25 g can increase the effectiveness of mycorrhizal hyphae colonization on soybean roots, which positively impacts water and nutrient uptake. However, at a dose of 35 g, there was no significant increase due to microbial saturation in the root area or competition among too densely packed hyphae. Conversely, a lower dose of 15 g was not yet effective enough to form a symbiosis that supports plant growth, thus showing no significant difference compared to higher doses. Meanwhile, a

dose of 0 g of mycorrhiza or without mycorrhiza has not been able to support plant growth in terms of water and nutrient uptake, thus not showing changes in the shoot dry weight. This supports the findings of (Guntoro et al., 2007), who found that although mycorrhizal inoculation promotes root infection and vegetative development, increasing the dose does not always correlate with increased crop yield.

Based on Table 3, the highest average shoot dry weight was found in treatment P2 (3-day interval) and was not significantly different from P3 (5-day interval). Meanwhile, the lowest average was found in treatment P1 and was not significantly different from treatment P0. This is because with watering every 3 days, the plants receive sufficient water, so the soil moisture condition remains stable. This supports optimal photosynthesis, which can increase biomass accumulation and the dry weight of the plant shoot. Meanwhile, in the 5-day interval, there is still water in the polybag or growing medium because the polybag uses a non-perforated plastic layer, so water is not lost and allows treatment P3 not to experience the dryness stress that should occur. Furthermore, watering once a day (P1) is also not good for the plants because overly wet soil can cause various problems, and treatment P0 (control) without watering results in excessive stress for the plants, which disrupts metabolic activities, resulting in a decrease in the dry weight of the plant shoot. According to (Juliantika et al., 2017), overwatering can damage plant roots; however, adequate watering can support photosynthesis, which will then be used to create plant biomass, affecting the dry weight of the plant canopy.

Table 3, it can be seen that the interaction between mycorrhizal fertilizer and irrigation interval on shoot dry weight shows that the highest average is found in treatment M1P2, which shows a similar response to treatments M2P3 and M3P3. This is because the optimum mycorrhizal dose of 15 g has been achieved, so further dose increases do not have a significant effect. In addition, an irrigation interval of once every three days provides optimal soil moisture conditions for root growth, which can help with water and nutrient uptake in plants and increase shoot dry weight. Observing each treatment, increasing the mycorrhizal dose allows for the plant to withstand stress for a longer period, in accordance with (Halimah, 2014) findings. This study shows that plant height, plant dry weight, and the number of seeds per pod are not significantly affected by arbuscular mycorrhiza. On the other hand, mycorrhiza produces more root bump.

**Stomatal Density**

The ANOVA test results showed that the stomatal density parameter in 6 WAP was significantly affected by mycorrhizal treatment, watering interval, as well as the interaction between watering interval and mycorrhiza, as shown in Table 4.

**Table 4**. Average stomatal density at 6 WAP

| Watering | Mycorrhiza | | | | Average |
|---|---|---|---|---|---|
| | M0 (0 g) | M1 (15 g) | M2 (25 g) | M3 (35 g) | |
| P0 (0 Day) | 7.417$^{g}$ | 11.517$^{cd}$ | 9.369$^{f}$ | 13.273$^{ab}$ | 10.394$^{c}$ |
| P1 (1 Day) | 9.955$^{ef}$ | 11.126$^{de}$ | 12.688$^{bc}$ | 12.102$^{bcd}$ | 11.468$^{b}$ |
| P2 (3 Days) | 11.712$^{cd}$ | 11.321$^{cde}$ | 12.688$^{bc}$ | 14.640$^{a}$ | 12.249$^{a}$ |
| P3 (5 Days) | 9.369$^{f}$ | 5.270$^{h}$ | 9.369$^{f}$ | 13.273$^{ab}$ | 9.321$^{d}$ |
| Average | 9.613$^{c}$ | 9.809$^{c}$ | 11.029$^{b}$ | 13.322$^{a}$ | |

According to Table 4, the M3 treatment has the highest average stomatal density as a result of mycorrhizal application, and it is significantly different from the M0, M1, and M2 treatments. Conversely, the M0 treatment has the lowest average stomatal density and is not significantly different from the M1 treatment. This indicates that the M3 dose of mycorrhiza is able to increase stomatal density compared to other doses of mycorrhiza, as mycorrhiza can enhance nutrient and water absorption with the help of its hyphae, which can help the plant maintain higher turgor. This can cause the stomata to open more, thereby increasing stomatal density and transpiration rate. Additionally, this supports the findings of (Saidah et al., 2018), which stated that mycorrhiza that have infected the host plant's roots will create dense hyphal networks and spread hyphae. This condition allows mycorrhizal plants to absorb more water during the dry season as well as macro and micronutrients, which in turn has a significant impact on the number of stomata.

The highest average stomatal density was found in treatment P2 with watering every 3 days, and it was significantly different from treatments P0, P1, and P3, while the lowest average stomatal density was in treatment P3 with watering every 5 days, and it was significantly different from treatments P1, P2, and P3. This is because watering every 3 days (P2) creates a mild water stress that stimulates the formation of new stomata. This adaptation allows the plant to maintain gas exchange efficiency and photosynthesis. Plants need sufficient water and nutrients to grow and develop, and watering every 3 days still provides adequate water resources for the plants. Treatment P1 (watering every day) receives water more frequently but does not show

the highest average because in P1 there is no physiological stress, so it does not trigger the formation of new stomata and remains normal. In prolonged drought conditions such as P3 (watering every 5 days), plants reduce the number of stomata on the leaves as an adaptation to minimize water loss by reducing evaporation. Thus, the longer the plants are watered, the fewer stomata they have. Meanwhile, the lowest score is found in the P3 treatment with watering every 5 days due to prolonged drought stress on the plants, which reduces cell turgor, inhibiting stomata formation. This is in accordance with the research of (Toriq & Puspitawati, 2023). The number and density of stomata decrease as the watering duration increases. Conversely, the shorter the watering interval, the more stomata are produced because the plants have sufficient water, resulting in a higher stomatal density.

The treatment with 35 g of mycorrhizal interaction and a 3-day watering interval had the highest average and was substantially different from the other treatments, as shown in Table 4. This is due to the fact that a 35 g mycorrhizal infection in the plant roots can increase the root's capacity to absorb nutrients and water from the soil micropores needed for photosynthesis. When photosynthesis proceeds smoothly, more organic material is produced for use in cell division, thereby increasing the number of stomata. When plants are watered every three days, they receive an adequate supply of water, allowing them to have more stomata than when watered more frequently. Long-term watering causes plants to close their stomata as a drought defense mechanism, which reduces water loss through transpiration. If drought continues, plants will adapt by changing the number and density of their stomata. This is in accordance with research by (Kuswandi, 2015), which shows that mycorrhiza can help plants produce more leaves, chlorophyll, stomata, and transpiration rates to survive dry conditions caused by root infections. According to (Setiawan et al., 2014), extending the watering interval can reduce the dry weight of plants, which can be associated with changes in stomatal density due to water stress.

## CONCLUSION

1. The application of mycorrhiza at a dose of 15 g can increase the average root volume. Meanwhile, a mycorrhiza dose of 35 g can increase the average the number of leaves, stomatal density, root dry weight, and shoot dry weight.
2. The watering interval treatment P1 (1 day) was able to increase the average parameters of the number of leaves. Meanwhile, the watering interval P2 (3 days) was able to increase the average stomatal density and shoot dry weight. Then, the watering interval P3 (5 days) increased the average parameters of root dry weight and shoot dry weight.
3. The interaction of a 15 g mycorrhiza dose and a 1-day watering interval showed the highest averages in leaf number parameters. Meanwhile, the interaction of a 35 g mycorrhiza dose and a 3-day watering interval was increase the average in the stomatal density parameter. The interaction of a 35 g mycorrhiza dose and a 5-day watering interval was able to increase the average in, root dry weight, and shoot dry weight parameters.

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## CONFLICT OF INTEREST

The author declar that there is no conflict of interest regarding the publication of this paper.

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