Effects of Soil Water Content and Inoculation with Funneliformis mosseae on the Growth of Bretschneidera sinensis Seedlings (Postprint)

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Abstract

This study measured the mycorrhizal colonization rates of *Bretschneidera sinensis* under different water treatments (40%, 60%, 80%, 100%) and time points, along with morphological indices—including seedling height, ground diameter, and leaf number—and physiological parameters such as leaf malondialdehyde content and seedling survival rate, for both inoculated and control groups before and after water treatments. The results demonstrated that: at 60% relative water content, hyphal, arbuscular, and total colonization rates were highest; both low (40%) and high (80%) water contents were unfavorable for mycorrhizal fungal colonization of seedlings; under low water content conditions (40% and 60%), inoculated seedlings exhibited significantly lower malondialdehyde content compared to controls, indicating that inoculation with *Funneliformis mosseae* enhanced seedling tolerance to drought stress, whereas at high water contents (80% and 100%), inoculation effects were negligible; the suitable soil relative water contents for seedling growth under both natural and inoculated conditions were 80% and 60%; under identical water conditions, inoculated seedlings demonstrated higher survival rates than controls, with the maximum survival rate (90%) occurring at 60% relative water content, while survival rates were comparatively low at either 40% low water content or 100% saturated water content.

Full Text

Effects of Soil Water Content and Inoculation with *Funneliformis mosseae* on the Growth of *Bretschneidera sinensis* Seedlings

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Abstract

This study measured the mycorrhizal colonization rates of *Bretschneidera sinensis* under different water treatments (40%, 60%, 80%, and 100% relative soil water content) at various time points, along with morphological indices including seedling height, ground diameter, and leaf number, as well as leaf malondialdehyde content and seedling survival rate for both inoculated and control groups before and after water treatments. The results demonstrated that under 60% relative water content, the colonization rates of hyphae, arbuscules, and total colonization reached their maximum values. Both low water content (40%) and high water content (80%) were unfavorable for mycorrhizal fungal colonization of seedlings. Under low water content conditions (40% and 60%), the malondialdehyde content of inoculated seedlings was significantly lower than that of the control group, indicating that inoculation with *Funneliformis mosseae* could enhance seedling resistance to drought stress. However, no significant effects were observed under high water content conditions (80% and 100%). The optimal relative soil water contents for seedling growth were 80% under natural conditions and 60% under inoculated conditions. Under identical water conditions, the survival rate of inoculated seedlings exceeded that of the control group, with the highest survival rate (90%) observed at 60% relative water content. Seedling survival rates were relatively low under both 40% low water content and 100% saturated water content conditions.

Keywords: *Funneliformis mosseae*, water stress, *Bretschneidera sinensis*, survival rate

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Introduction

Bretschneidera sinensis, also known as Zhong E Mu or Shan Tao Hua, is a monotypic family species centered in China and represents a relict species of the Tertiary paleotropical flora, holding significant scientific value for studying angiosperm phylogeny, paleogeography, and paleoclimatology (Chen, 1984; Wu, 1991). This species is sporadically distributed in mountainous forest regions south of the Yangtze River in China. Due to severe habitat destruction, scarce maternal tree resources, low seedling survival rates, and difficult natural regeneration, *B. sinensis* has become rare and endangered. It was listed as a national first-class key protected wild plant in 1999 and assessed as endangered in the *China Species Red List* (Yu, 1999; Wang & Xie, 2004).

The growth process of *B. sinensis* experiences two bottleneck periods: the transition from seed to seedling and from seedling to mature plant. While the seed-to-seedling transition has been achieved through physical and mechanical methods (Wu et al., 2006; Zhang et al., 2011), the technical challenges associated with the seedling-to-mature-plant transition remain unresolved. The fundamental reason lies in the unclear identification of key ecological factors limiting seedling growth and their mechanisms of action. Ecological anatomical characteristics of *B. sinensis* stems indicate small vessel diameters and relatively low water transport efficiency, with seedlings having higher water transport demands than mature plants (Fei et al., 1999). Additionally, the rare differentiation of root hairs on the root tip surface limits water and mineral nutrient absorption. Consequently, high summer temperatures and drought have become the primary causes of high mortality in one-year-old *B. sinensis* seedlings (Qiao et al., 2010; 2011).

Arbuscular mycorrhizal fungi (AMF) are obligate symbiotic endomycorrhizae commonly found in plants, forming arbuscular mycorrhizal symbioses with the roots of approximately 80% of terrestrial plants on Earth (Smith & Read, 2008; Wang & Qiu, 2006). Numerous studies have demonstrated that AMF can enhance plant drought resistance (Brachmann & Parniske, 2006; Chen et al., 2014; Huang et al., 2017; Xu et al., 2017; Zhang et al., 2017; Jia et al., 2017). *Funneliformis mosseae* (formerly *Glomus mosseae*) is a common AMF species in the native habitat soil of *B. sinensis* (Qiao et al., 2015). Huang & Zhuang (2000) reported the presence of *Glomus* and *Acaulospora* spores in the rhizosphere soil of *B. sinensis*, along with arbuscular and vesicular structures in its mycorrhizae. Zhao et al. (2018) found that AMF could alleviate stress damage and enhance plant stress resistance by inoculating marigold seedlings with *F. mosseae*. Wang et al. (2018) discovered that inoculating stevia with *F. mosseae* improved its salt tolerance. Qiao et al. (2015) found that *F. mosseae* could enhance superoxide dismutase (SOD) activity and promote seedling growth in *B. sinensis*. However, no studies have reported on the combined effects of different soil water contents and *F. mosseae* inoculation on *B. sinensis* seedling growth.

This study selected *F. mosseae*, a common AMF species in the habitat soil of *B. sinensis*, as the experimental fungus. By measuring mycorrhizal colonization rates at different water treatments and time points, morphological indices such as seedling height, ground diameter, and leaf number before and after water treatments, leaf malondialdehyde content, and seedling survival rate, we investigated the effects of different water treatments and *F. mosseae* inoculation on the growth and survival capacity of *B. sinensis* seedlings. This research provides a theoretical basis for identifying key ecological factors limiting *B. sinensis* seedling growth and their mechanisms of action.

Materials and Methods

1.1 Experimental Materials

1.1.1 Plant Materials Mature seeds of *B. sinensis* were collected in November 2016 from Nankunshan National Forest Park in Guangdong (113°53 E, 23°38 N). The thousand-seed weight was 1786.0 g. After removing the orange-red arils, seeds were stored in moist sand in seedling trays. Germination began in January 2017, and in early April, when seedlings reached 20 cm in height, they were transplanted into sterilized substrate.

1.1.2 Experimental Site and Substrate The experiment was conducted at the experimental base of South China Botanical Garden in Guangzhou (113°21 E, 23°10 N) within a semi-controlled greenhouse (rain-sheltered with one layer of shade netting). The substrate consisted of peat:coconut coir:river sand at a 1:1:2 ratio, mixed uniformly and sterilized in an autoclave at 0.15 MPa and approximately 120°C for 2 h. After air-drying for one week, the substrate was placed in pots with a bottom diameter of approximately 16 cm. The dry weight of substrate was 1470.0 g per pot, with a maximum water holding capacity of 0.76.

1.1.3 Fungal Inoculum The AMF species used was *Funneliformis mosseae*, obtained from the "Arbuscular Mycorrhizal Fungi Germplasm Resource Bank (BGC)" at the Institute of Plant Nutrition and Resource Sciences, Beijing Academy of Agriculture and Forestry Sciences. The inoculant consisted of fungal spores, hyphae, infected root fragments, and mixed substrate. *F. mosseae* soil was mixed uniformly, and 14.0 g of inoculant was added to each pot using a three-point inoculation method, with a total of 80 potted plants inoculated.

1.1.4 Experimental Design and Methods The experiment included one *F. mosseae* inoculation treatment (Group A) and one blank control (CK, Group B). One seedling was planted per pot, with Group A receiving 14.0 g of inoculant per pot. For two months post-inoculation, seedlings received normal watering and fertilization with phosphorus-reduced Hoagland nutrient solution every two weeks (Wang et al., 2012). The blank control Group B received no inoculant but identical water and fertilizer conditions. Water treatments began on July 1, 2017, and ended on July 31, 2017, with four gradients of relative soil water content maintained at 40%, 60%, 80%, and 100%. Each pot contained 1470.0 g $\pm$ 5 g of dry soil, with post-treatment weights of (2000.0 $\pm$ 5) g, (2200.0 $\pm$ 5) g, (2400.0 $\pm$ 5) g, and (2600.0 $\pm$ 5) g, respectively (relative soil water content = soil water content/field capacity $\times$ 100%). A total of 4 $\times$ 2 treatments were established, with 16 replicates per treatment (16 pots each).

The experimental containers were plastic nursery pots with top diameter, height, and bottom diameter of 180 mm, 180 mm, and 140 mm, respectively. After water treatment, normal watering was resumed, and survival counts were recorded

30 days later (August 30, 2017) to calculate survival rates. Plant height, base diameter, leaf number, and leaflet number were measured periodically. Mycorrhizal colonization rates were measured before water treatment (45 days post-inoculation), at the start of water treatment (60 days post-inoculation), mid-treatment (75 days post-inoculation), and at treatment end (90 days post-inoculation). Leaf malondialdehyde (MDA) content was measured every 10 days during the water treatment period.

1.2 Measurement Indicators

1.2.1 Morphological Indices Nine seedlings per treatment were selected at the start and end of water treatment to measure plant height using a ruler and base diameter using electronic calipers. Leaf number and leaflet number were recorded every 15 days after water treatment began. Water treatment concluded at 30 days, after which plants returned to normal maintenance.

1.2.2 Mycorrhizal Colonization Rate Before water treatment (45 days post-inoculation), at treatment start (60 days post-inoculation), mid-treatment (75 days post-inoculation), and treatment end (90 days post-inoculation), samples were collected from both inoculated (Group A) and control (Group B) plants for measurement. Three seedlings per treatment were selected, and fresh root systems were cut into approximately 1 cm segments, rinsed with clean water, and fixed with FAA fixative. Root segments were stained using the Trypan blue method. Forty root segments were selected for slide preparation and observed under an optical microscope (Leica DM2000) at 40× magnification. Hyphal, arbuscular, and vesicular structures were examined. Any field of view containing any of these structures counted as +1 for the respective structure and +1 for total colonization. If two or more structures appeared in a single field, each structure count increased by 1, and total colonization count increased by 1. A total of 200 fields were observed per sample.

The colonization rate calculation formulas were: - Total colonization rate (TC) = Total colonization count/200 × 100% - Hyphal colonization rate (HC) = Hyphal colonization count/200 × 100% - Arbuscular colonization rate (AC) = Arbuscular colonization count/200 × 100% - Vesicular colonization rate (VC) = Vesicular colonization count/200 × 100%

1.2.3 Malondialdehyde Content The thiobarbituric acid method was used (Li, 2000). For each treatment, three seedlings were selected, and 0.3 g of leaflets from the same position were collected, washed, dried, and placed in a pre-cooled mortar. A small amount of quartz sand and 2.0 mL of 10% TCA were added, and the sample was ground into homogenate in an ice bath. The homogenate was transferred to a centrifuge tube, and the mortar and pestle were rinsed several times with 3.0 mL of TCA, with rinsate transferred to the centrifuge tube. The homogenate was centrifuged at 3000 $r \cdot min^{1}$ for 10 min, and the supernatant was transferred to a stoppered test tube and brought to 5.0 mL

(V) with 10% TCA solution. Then, 2.0 mL of supernatant was placed in a stoppered test tube, mixed with 2.0 mL of 0.5% TBA (V), heated in a boiling water bath for 20 min, rapidly cooled, and centrifuged again. The supernatant was measured for optical density at 532 nm, 600 nm, and 450 nm. Equipment used included a Shanghai Shunyu Hengping FA2004 electronic analytical balance, Beijing Yongguangming XMTD-4000 electric constant temperature water bath, Xiangyi H-2050R tabletop high-speed refrigerated centrifuge, and Shanghai Youke UV759CTR UV-Vis spectrophotometer.

MDA content (mol/g) =

(formula with A450, A532, A600)

Where A450, A532, and A600 represent absorbance values at 450 nm, 532 nm, and 600 nm, respectively. V represents the total volume of sample extract (mL), V represents the sample extract volume in the color reaction (mL), and W represents fresh leaf weight.

The corrupted formula fragment: WVVAAAS 045056.060053245.6

1.2.4 Survival Rate Thirty days after resuming normal watering, survival counts were recorded for each treatment, and survival rates were calculated as: Survival rate = (Number of surviving plants per treatment/Total number of plants per treatment) × 100%.

Results

2.1 Changes in Colonization Rate

As shown in Figure 1 [Figure 1: see original paper], colonization rates of various structures and total colonization differed across time points and water conditions. From 45 to 60 days post-inoculation, colonization rates of hyphae, arbuscules, vesicles, and total colonization all increased significantly. Hyphal colonization rate increased from (1.17 ± 0.25)% to (5.00 ± 0.45)%, representing the largest proportion of total colonization. Arbuscular colonization rate increased from (0.33 ± 0.25)% to (1.83 ± 0.25)%, showing the fastest growth rate. Vesicular colonization rate increased from (0.67 ± 0.49)% to (2.17 ± 0.25)%. Total colonization rate increased from (1.83 ± 0.25)% to (7.17 ± 0.25)%.

After water treatment began, differences in colonization rates among water treatments became apparent. At 75 days, under 60% relative water content, hyphal, arbuscular, and total colonization rates were highest at (15.67 ± 1.15)%, (5.17 ± 0.76)%, and (22.33 ± 1.53)%, respectively, while all three rates decreased under 80% and 100% relative water content. Similar results occurred at 90 days, with hyphal, arbuscular, and total colonization rates higher than at 60 days, reaching (19.33 ± 1.53)%, (5.67 ± 0.58)%, and (23.00 ± 1.00)%, respectively. This suggests that over time, low water content below 60% facilitated hyphal and arbuscular proliferation and continuous root colonization, whereas high water content above 80% was unfavorable. Vesicles showed higher colonization rates under high water content above 80% compared to low water content below 60%. At 70 days, vesicular colonization rate was highest at (11.50 ± 1.32)% under 100% relative water content, while at 90 days, it was highest at (12.67 ± 0.58)% under 80% relative water content.

Pearson correlation analysis revealed a significant positive correlation between water content and vesicular colonization rate ($p = 0.001$), indicating that higher water content facilitated vesicle formation by mycorrhizal fungi.

Before water treatment, *F. mosseae* showed low colonization rates, with only small amounts of hyphae, vesicles, and arbuscules visible in seedling root cortex tissues (Figure 2 [Figure 2: see original paper]). Total colonization rates after water treatment ((7.67 ± 0.76)%-(23.00 ± 1.00)%) were higher than before treatment ((1.83 ± 0.25)%-(7.17 ± 0.25)%), likely due to increased root growth over time and continuous proliferation of mycorrhizal fungal structures, which increased contact probability and total colonization rates.

2.2 Changes in Leaf Malondialdehyde Content Under Different Water Treatments

Malondialdehyde is a substance produced by plants under stress and can reflect the degree of environmental stress to some extent (Zhao et al., 2018). The changing trends in MDA content were generally similar between inoculated and control groups. As water treatment progressed, the 40% water content group showed an initial increase followed by a decrease in MDA content. The inoculated group showed values of (36.12 ± 0.13)-(53.01 ± 1.53)-(111.47 ± 1.08)-(65.84 ± 0.10) nmol · g ^{1}FW, while the control group showed (41.92 ± 0.40)-(63.76 ± 1.68)-(138.35 ± 2.39)-(85.55 ± 0.38) nmol · g ^{1}FW. Both groups peaked at 20 days, with inoculated group MDA content lower than the control. The 60% water content treatment group also showed an initial increase followed by a decrease: inoculated group values were (36.12 ± 0.13)-(50.27 ± 1.32)-(44.0 ± 1.93)-(42.17 ± 1.45) nmol · g ^{1}FW, while control values were (41.92 ± 0.40)-(47.04 ± 0.38)-(124.15 ± 1.33)-(42.25 ± 0.32) nmol · g ^{1}FW. The 80% water content treatment group showed a continuous slow decline in MDA content. The 100% water content group showed an initial increase followed by a decrease: inoculated group values were (36.12 ± 0.13)-(39.45 ± 0.59)-(56.58 ± 0.10)-(45.39 ± 1.72) nmol · g ^{1}FW, while control values were (41.92 ± 0.40)-(42.38 ± 0.84)-(37.01 ± 2.30)-(35.62 ± 0.91) nmol · g ^{1}FW.

Based on these MDA content fluctuations, we infer that when relative soil water content was below 60%, *B. sinensis* seedlings experienced some degree of drought stress, while relative soil water content exceeding 80% caused some waterlogging damage. Inoculation with *F. mosseae* reduced seedling MDA content, which is beneficial for enhancing seedling resistance to drought stress.

2.3 Morphological Changes

Before water treatment (60 days post-inoculation), no significant differences were observed between inoculated and control groups in plant height, base diameter, compound leaf number, or leaflet number ($p > 0.05$) (Table 1). As shown in Table 2 , for the inoculated group, plant height showed no significant differences 30 days after water treatment, but height increment (3.03 ± 0.91 cm) and base diameter increment (1.76 ± 0.33 mm) under 60% relative water content were significantly higher than other treatments. In the non-inoculated group, height increment (2.02 ± 0.20 cm) and base diameter increment (1.84 ± 0.16 mm) under 80% relative water content were higher than other treatments. Table 3 shows that both compound leaf number and leaflet number decreased in both groups. At 15 days after water treatment began, no significant differences were observed among groups. At 30 days, the inoculated group under 60% relative water content had more compound leaves and leaflets than other groups, while in the control group, 80% relative water content showed superior compound leaf and leaflet numbers. These results indicate that inoculated seedlings grew better under 60% relative water content, while naturally growing seedlings without inoculation thrived at approximately 80% relative soil water content. However, under low water content conditions (40% and 60%), height and base diameter increments were higher in the inoculated group than in the non-inoculated group, whereas the opposite occurred under high water content conditions (80% and 100%).

2.4 Seedling Survival Rate

As shown in Table 4 , survival rates 30 days after resuming normal watering demonstrated that under identical water conditions, survival rates in the inoculated group (Group A) were higher than in the control group (Group B), indicating that *F. mosseae* inoculation improved one-year-old *B. sinensis* seedling survival rates. The inoculated group achieved highest survival rate (90%) at 60% relative water content, while the non-inoculated group showed highest survival rate (85%) at 80% relative water content. Seedling survival rates were relatively low under both 40% low water content and 100% saturated water content conditions, which are unfavorable for seedling growth, particularly evident under 40% relative water content, indicating that drought had a greater impact on seedling survival rates.

Discussion

3.1 Effects of Different Water Contents on *Funneliformis mosseae* Colonization Rate

García et al. (2008) studied AMF in *Lotus tenuis* and found that excessive or deficient soil water reduced arbuscule and hyphal structure formation, while excessive water increased vesicle formation rate by 256% with little effect from water deficit. Our study similarly demonstrated that different water conditions affected hyphal, vesicular, and arbuscular structure formation and total colonization rates. At 60% relative soil water content, hyphal and arbuscular colonization rates reached maximum values. At 100% relative water content, hyphal and arbuscular colonization rates were significantly lower than at 80% and 60% ($p < 0.05$), showing a "single-peak" trend consistent with AMF as aerobic organisms (He et al., 2008). When soil water content was too high, soil aeration decreased, significantly reducing hyphal and arbuscular colonization while increasing resistant vesicle structures. The inoculated group showed increasing hyphal and arbuscular colonization rates only below 60% relative water content, facilitating hyphal and arbuscular structure formation. This high colonization rate under drought conditions indicates that as an endophytic fungus, *F. mosseae* increased colonization to enhance drought tolerance in *B. sinensis*. Correlation analysis showed a significant positive correlation between water content and vesicular colonization rate, indicating that higher water content facilitated vesicle formation, consistent with García et al. (2008). However, vesicular colonization rate decreased under 100% relative water content (waterlogging), suggesting excessive water was also unfavorable for vesicular colonization.

3.2 Effects of *Funneliformis mosseae* Inoculation on Seedling Physiology Under Water Stress

Research has shown that AMF inoculation enhances plant stress resistance. Mo (2016) studied drought-stressed watermelon inoculated with *Glomus versiforme* and found that AMF improved leaf relative water content and chlorophyll content, promoted plant growth, particularly root growth, and alleviated drought damage to chloroplasts. Wu et al. (2006) found that AMF inoculation reduced MDA, H O , and O content in citrus leaves and roots, increased antioxidant enzyme activities (SOD, POD, CAT, GR, and APX) and antioxidant contents (ASC, GSH), thereby reducing oxidative damage from water stress and giving mycorrhizal citrus a more advantageous position under water stress. Qiao et al. (2015) found that *F. mosseae* enhanced SOD activity, increased soluble sugar, chlorophyll, and water content, and promoted seedling growth and survival in *B. sinensis*. However, further research is needed on how AMF inoculation affects *B. sinensis* resistance through MDA content analysis.

When plants are stressed, the balance between reactive oxygen species production and scavenging may be disrupted. As stress duration and intensity increase, the reactive oxygen scavenging system composed of superoxide dismutase (SOD), peroxidase (POD), catalase (CAT), ascorbate peroxidase (AsAPOD), and non-enzymatic antioxidants such as ascorbic acid (ASC) and glutathione (GSH) gradually declines in function. Accumulating reactive oxygen species cause membrane lipid peroxidation and free radical chain reactions, forming malondialdehyde (MDA), which reduces membrane fluidity and damages membrane function. MDA accumulation may cause membrane and cellular damage and reflects the degree of environmental stress on plants, with plant stress resistance negatively correlated with MDA content under environmental stress (Zhao et al., 2018). In this study, both inoculated and control groups showed an initial increase followed by decrease in MDA content under low water content below 60% (drought stress), with inoculated group MDA content significantly lower than the non-inoculated group. Under such stress conditions, the significant reduction in MDA content may result from AMF stimulation of the antioxidant enzyme system, which removed reactive oxygen species, reduced membrane lipid peroxidation, and consequently decreased MDA production. Lower MDA content indicates less membrane function damage, reflecting that *F. mosseae* inoculation improved seedling resistance to water stress to some extent. The 100% water content (waterlogging) treatment group showed an initial increase followed by decrease in MDA content, indicating some waterlogging damage, with inoculated group MDA content higher than the control group. This may be because high water conditions reduced total colonization rates and were unfavorable for hyphal and arbuscular structure formation, making the role of *F. mosseae* less significant.

3.3 Effects of Different Water Contents on Seedling Growth and Survival

Previous studies have reported that arbuscular mycorrhizal colonization promotes or improves plant root water and mineral nutrient absorption, increases root water content (Li & Cao, 1993; Smith, 2001; Aroca et al., 2007), and improves rhizosphere microenvironments (Harrison, 1999; Shenoy & Kalagudi, 2005), thereby promoting plant growth. Our results showed that inoculated *B. sinensis* seedlings grew best at 60% relative water content with highest survival rates. Since hyphal, arbuscular, and total colonization rates were also highest at 60% relative water content, this indicates that 60% relative water content is an optimal condition for both seedling growth and *F. mosseae* colonization. Inoculation with *F. mosseae* improved seedling growth capacity under drought stress. However, under high water content (80% and 100%), height and base diameter increments in the inoculated group were lower than in the non-inoculated group, opposite to the pattern observed under low water content (40% and 60%), possibly because seedlings had some tolerance to short-term water stress. Under non-inoculated conditions, *B. sinensis* seedlings grew better at 80% relative water content, indicating an interaction between soil water content and AMF, where *F. mosseae* inoculation enabled *B. sinensis* seedlings to grow and survive under lower water conditions. Under identical relative water content conditions, survival rates in the inoculated group were higher than in the non-inoculated group, likely because mycorrhizal colonization formed a symbiotic relationship that enhanced plant water stress resistance and improved survival rates. Seedling survival rates under 100% high water content were significantly higher than under 40% low water content, possibly because *B. sinensis* seedlings had some tolerance to short-term water stress but were more sensitive to drought stress.

Conclusion

This study analyzed colonization rates, morphological and physiological indices, and survival rates before and after *F. mosseae* inoculation and different water treatments. We conclude that different water conditions affect hyphal, vesicular, and arbuscular structure formation and total colonization rates in *F. mosseae*, with 60% relative soil water content being optimal for mycorrhizal fungal colonization. Both low water content (40%) and high water content above 80% were unfavorable for mycorrhizal fungal colonization of seedlings. Under low water content conditions (40% and 60%), MDA content in inoculated seedlings was significantly lower than in controls, indicating that *F. mosseae* inoculation improved seedling resistance to drought stress, though effects were not obvious under high water content conditions (80% and 100%). Regarding effects of different water contents on seedling growth and survival, 60% relative water content was optimal for both seedling growth and *F. mosseae* colonization, with inoculation improving seedling growth capacity under drought stress. *Bretschneidera sinensis* seedlings had some tolerance to short-term water stress but were more sensitive to drought stress. Under natural conditions, the suitable relative soil water content for seedling growth was 80%. Under identical water conditions, inoculated seedlings showed higher survival rates than controls, with *F. mosseae* inoculation improving seedling survival rates, particularly achieving the highest rate (90%) at 60% relative water content. Seedling survival rates were relatively low under both 40% low water content and 100% saturated water content conditions. This study provides a reference for solving key technical problems in *B. sinensis* breeding and advancing endangered species conservation efforts.

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Note: Figure translations are in progress. See original paper for figures.