The user wants me to translate a Chinese academic paper title to English. The title is: "植物生理参数对长期干旱期间土壤水分有效性的响应受土壤质地影响的后印本" Let me break this down: - 植物生理参数 = plant physiological parameters - 对…的响应 = response to …- 长期干旱期间 = during prolonged drought - 土壤水分有效性 = soil water availability - 受…影…

Authors: HUANG Laiming, ZHAO Wen, The user has provided a single name: "SHAO Ming'an". This appears to be a Chinese name that needs to be translated or romanized.

Let me analyze this: - This is a person' s name in Chinese - The format is: SHAO Ming' an - SHAO is the surname (邵 in Chinese) - Ming' an is the given name (明安 in Chinese)

The user wants me to translate this from Simplified Chinese to English. However, names are typically not translated but rather transliterated. The current form "SHAO Ming' an" is already in Pinyin (the romanization system for Chinese).

The instruction says "Translate from Simplified Chinese to English with the highest accuracy and academic tone." But this is just a name. In academic contexts, Chinese names are typically presented in one of these formats: 1. SHAO Ming-an (with hyphen) 2. Shao Ming' an (with only first letter capitalized) 3. Ming' an Shao (Western order, given name first) 4. SHAO, Ming' an (comma-separated)

Looking at the glossary provided: - 机器学习 => machine learning - 深度学习 => deep learning

These don' t apply to a name.

The critical requirements mention: - Preserve LaTeX commands and math placeholders - Preserve citation commands - Preserve …tags - Maintain academic tone

But there are no LaTeX commands, citations, or paragraph tags in this input. It' s just a name.

The output rules say: - Return ONLY the translated text - Keep one output paragraph per input paragraph - Maintain exact count and IDs of tags

Since there' s no paragraph tag, I should just return the name in an appropriate academic format.

In academic papers, Chinese names are often written with the surname in all caps to avoid confusion about which is the surname. So "SHAO Ming' an" is actually already in a good format for academic use.

However, sometimes the hyphen is added in the given name: "SHAO Ming-an" . But the original doesn' t have a hyphen.

Let me check standard academic practice: - Many journals use: SURNAME Given-name - Or: Surname, Given-name - Or: Given-name Surname

For Chinese names specifically, the format "SHAO Ming' an" (surname in all caps, given name in title case) is very common in academic literature to clearly identify the surname.

Since the input is already "SHAO Ming' an" , and this, The user has provided a name "SHAO Ming' an" which appears to be a Chinese name. This is likely part of a larger document that needs translation. However, the current input is just the name itself.

Let me think about how to handle this:

1. The name "SHAO Ming' an" should be transliterated according to standard academic conventions
2. In academic papers, Chinese names are typically written with the surname first, followed by the given name
3. The surname "SHAO" should remain in uppercase or capitalized form
4. The given name "Ming' an" should be properly formatted

Standard conventions: - Surname: SHAO (all caps) or Shao (capitalized) - Given name: Ming' an or Ming-An or Mingan

In most academic contexts, Chinese names are written as: - SHAO Ming' an (surname in all caps, given name with apostrophe) - Shao Ming' an (both capitalized normally) - SHAO, Ming' an (comma-separated)

The most common format in academic papers is "SHAO Ming' an" or "Shao Ming' an" . The apostrophe in "Ming' an" is important to indicate the separate characters 明 (Ming) and 安 (an).

Since this appears to be a standalone name, and the user is asking for translation following the strict rules for academic papers with LaTeX commands, tags, etc., but there are no such elements in this input, I should just provide the properly formatted English version of the name.

However, I need to check if this might be part of a larger context. The user might be testing the system or this could be the first line of a document. The instructions say to preserve ALL tags, but there are none here. I should just translate the name as is.

The most standard academic format would be "SHAO Ming' an" (surname in all caps, given name with apostrophe). Some journals prefer "Shao Ming' an" . I' ll go with the more formal "SHAO Ming' an" as it' s common in many academic publications.

Wait, let me reconsider. The user provided just "SHAO Ming' an" - but this is already in a form that looks like an English transliteration. The surname SHAO is already in uppercase. The given name "Ming' an" already has the apostrophe.

Is the user asking me to confirm this format? Or is this a test? The instructions say "Translate from

Date: 2021-08-06T00:00:00+00:00

Abstract

The user wants me to translate a scientific abstract from English to English. Wait, let me re-read the prompt.

The prompt says: "You are a professional scientific translator specializing in academic papers. Translate from Simplified Chinese to English···"

But the text provided is already in English. Let me check the text again:

"Soil water deficit is increasingly threatening the sustainable vegetation restoration and ecological construction on the Loess Plateau of China due to the climate warming and human activities. To determine the response thresholds of Amygdalus pedunculata (AP) and Salix psammophila (SP) to soil water availability under different textural soils, we measured the changes in net photosynthetic rate (Pn), stomatal conductance (Gs), intercellular CO2 concentration (Ci), leaf water potential (w), water use efficiency (WUE) and daily transpiration rate (Td) of the two plant species during soil water content (SWC) decreased from 100% field capacity (FC) to 20% FC in the sandy and loamy soils on the Loess Plateau in the growing season from June to August in 2018. Results showed that Pn, Gs, WUE and Td of AP and SP remained relatively constant at the beginning of soil water deficit but decreased rapidly as plant available soil water content (PASWC) fell below the threshold values in both the sandy and loamy soils. The PASWC thresholds corresponding to Pn, Gs and Ci of AP in the loamy soil (0.61, 0.62 and 0.70, respectively) were lower than those in the sandy soil (0.70, 0.63 and 0.75, respectively), whereas the PASWC thresholds corresponding to Pn, Gs and Ci of SP in the loamy soil (0.63, 0.68 and 0.78, respectively) were higher than those in the sandy soil (0.58, 0.62 and 0.66, respectively). In addition, the PASWC thresholds in relation to Td and WUE of AP (0.60 and 0.58, respectively) and SP (0.62 and 0.60, respectively) in the loamy soil were higher than the corresponding PASWC thresholds of AP (0.58

and 0.52, respectively) and SP (0.55 and 0.56, respectively) in the sandy soil. Furthermore, the PASWC thresholds for the instantaneous gas exchange parameters (e.g., Pn and Gs) at the transient scale were higher than the thresholds for the parameters (e.g., Td) at the daily scale. Our study demonstrates that different plant species and/or different physiological parameters exhibit different thresholds of PASWC and that the thresholds are affected by soil texture. The result can provide guidance for the rational allocation and sustainable management of reforestation species under different soil conditions in the loess regions."

This is already in English. The user might have made a mistake. However, the instructions are very specific about preserving tags, LaTeX commands, etc. But there are no tags in the input.

Let me re-read the instructions carefully: - "Translate from Simplified Chinese to English" - "Preserve ALL …paragraph wrapper tags EXACTLY" - "Return ONLY the translated text for the given input (no explanations, no quotes, no headings you invent)." - "Keep one output paragraph per input paragraph; do not merge or split paragraphs." - "Maintain exact count and IDs of …tags"

The input text is a single paragraph without any tags. Since the text is already in English, there are two possibilities: 1. The user made a mistake and provided English text instead of Chinese 2. This is a test to see if I follow instructions correctly

Given the strict requirements about tags, and the fact that there are none in the input, I should probably just return the text as-is, since: - There' s nothing to translate (it's already English) - There are no tags to preserve - The instructions say "Return ONLY the translated text"

But wait, let me check if there might be any Chinese characters hidden or if I' m missing something. The text appears to be pure English academic writing.

The most logical interpretation is that the user wants me to process this text according to the rules, which means: 1. Since it' s already in English, no translation is needed 2. Since there are no tags, I don' t need to add any 3. I should return the text exactly as provided

However, the instructions are very specific about tags. Let me think about edge cases. Perhaps the user expects me to wrap the entire text in a tag? But the instructions say "Preserve ALL …paragraph wrapper tags EXACTLY" - which implies they should already be present.

Given that: - The source text is English, not Chinese - There are no tags to preserve - The instructions are explicit about not adding anything

The safest approach is to return the text exactly as provided, with no modifications. This follows the "Return ONLY the translated text" rule, and since no translation is needed, the text itself is the output

Full Text

Abstract

Soil water deficit is increasingly threatening sustainable vegetation restoration and ecological construction on the Loess Plateau of China due to climate warming and human activities. To determine the response thresholds of *Amygdalus pedunculata* (AP) and *Salix psammophila* (SP) to soil water availability under different soil textures, we measured changes in net photosynthetic rate (P_n), stomatal conductance (G_s), intercellular CO_2 concentration (C_i), leaf water potential (ψ_w), water use efficiency (WUE), and daily transpiration rate (T_d) in these two species as soil water content (SWC) decreased from 100% field capacity (FC) to 20% FC in both sandy and loamy soils during the growing season from June to August 2018. Results showed that P_n, G_s, WUE, and T_d of both AP and SP remained relatively constant at the beginning of soil water deficit but decreased rapidly as plant available soil water content (PASWC) fell below threshold values in both soil types. The PASWC thresholds corresponding to P_n, G_s, and C_i of AP in loamy soil (0.61, 0.62, and 0.70, respectively) were lower than those in sandy soil (0.70, 0.63, and 0.75, respectively), whereas the PASWC thresholds for P_n, G_s, and C_i of SP in loamy soil (0.63, 0.68, and 0.78, respectively) were higher than those in sandy soil (0.58, 0.62, and 0.66, respectively). Additionally, the PASWC thresholds related to T_d and WUE of AP (0.60 and 0.58, respectively) and SP (0.62 and 0.60, respectively) in loamy soil were higher than the corresponding thresholds for AP (0.58 and 0.52, respectively) and SP (0.55 and 0.56, respectively) in sandy soil. Furthermore, PASWC thresholds for instantaneous gas exchange parameters (e.g., P_n and G_s) at the transient scale were higher than thresholds for parameters at the daily scale (e.g., T_d). Our study demonstrates that different plant species and physiological parameters exhibit different PASWC thresholds, and that these thresholds are affected by soil texture. These results can provide guidance for the rational allocation and sustainable management of reforestation species under different soil conditions in loess regions.

Keywords: plant available soil water content; drought stress; soil water deficit; sustainable vegetation restoration; sandy soil; loamy soil; Loess Plateau

1 Introduction

Soil moisture is a critical factor limiting productivity in terrestrial ecosystems of arid and semi-arid regions worldwide [?, ?]. Due to natural climate change and anthropogenic activities, the frequency and intensity of drought stress affecting plant growth in these regions are projected to increase continuously [?]. Severe drought stress significantly reduces soil water availability and plant productivity [?, ?, ?]. Consequently, plant physiological responses to drought stress have been extensively studied by ecologists in recent years [?, ?, ?]. Research has demonstrated that drought stress damages plant growth by limiting CO_2 uptake and reducing photosynthetic activity [?]. However, different plant types and different physiological parameters within the same species show varying sensitivities to increasing drought intensity [?, ?]. For instance, Blackman et al. [?] examined changes in leaf water potential, leaf hydraulic conductance, and midday transpiration in four temperate woody species under different drought conditions, finding substantial variations in drought tolerance that were closely related to leaf hydraulic vulnerability. These species-specific differences in hydraulic properties play important roles in determining plant recovery rates during re-wetting. Yan et al. [?] investigated responses of various physiological parameters to prolonged drought in commonly reforested plants on the Loess Plateau, defining plant available soil water content (PASWC) as the ratio of soil water content to field capacity ($PASWC = SWC/FC$). Their results showed that leaf water status, gas exchange, and fluorescence parameters remained unchanged when PASWC exceeded a threshold value but changed rapidly when PASWC fell below it, with threshold values varying significantly among physiological parameters. Similarly, Wu and Huang [?] reported significant differences in PASWC thresholds for various physiological parameters in maize and noted that these thresholds were significantly affected by soil texture. Since PASWC is a principal factor limiting plant growth and development in terrestrial ecosystems, quantifying PASWC thresholds across different plant and soil types can provide valuable guidance for sustainable vegetation restoration. Despite extensive research on plant physiological responses to soil water stress [?, ?, ?, ?], few studies have examined quantitative relationships between plant physiological parameters and SWC due to site-specific differences [?, ?, ?], making it difficult to select appropriate evaluation parameters for PASWC across different plant and soil types. Therefore, further research is needed to quantitatively model how physiological parameters respond to PASWC under varying soil textures and vegetation types.

The Loess Plateau of China suffers from severe erosion and water shortage [?]. Large-scale afforestation since 1999 has accelerated soil water depletion, leading to widespread formation of dried soil layers [?, ?] that limit reliable soil water supply and threaten sustainable vegetation restoration [?]. Previous studies have shown that soil water availability remains relatively stable when SWC exceeds a threshold value but declines rapidly when SWC drops below it [?, ?]. When SWC is above the PASWC threshold, plant physiological parameters remain relatively stable despite decreasing SWC. However, when SWC falls below the PASWC threshold, physiological parameters either decrease rapidly (e.g., P_n and T_d) or increase rapidly (e.g., C_i and ψ_w) with further SWC reduction [?, ?, ?]. Sadras and Milroy [?] noted through literature review that PASWC thresholds vary with plant type, physiological parameter, and soil texture, and that even plants of the same species but different genotypes exhibit different thresholds. The Loess Plateau exhibits substantial spatial variation in soil texture and extensive distribution of artificial vegetation [?]. Investigating PASWC thresholds of typical plants grown in different soil textures and understanding their differences can provide a scientific basis for formulating site-appropriate vegetation restoration measures. However, previous studies have focused primarily on PASWC thresholds of single crops or on woody and herbaceous plants grown in soils of the same texture, with few examining thresholds for typical plants across different soil texture types. Thus, there is an urgent need to investigate response thresholds of physiological parameters to prolonged drought across different soil textures and vegetation types to guide rational allocation and sustainable management of reforestation species under varying soil and water conditions on the Loess Plateau.

Amygdalus pedunculata (AP) and *Salix psammophila* (SP) are excellent windbreak and sand-fixation tree species widely distributed on the northern Loess Plateau [?]. In recent years, national and local governments have promoted large-scale planting of AP and SP to accelerate desertification control. However, drought and water shortage remain key factors limiting large-scale vegetation restoration in this region. Determining PASWC thresholds for AP and SP across different soil textures is crucial for rational spatial planning and sustainable vegetation restoration. This study characterizes response thresholds of P_n, G_s, C_i, ψ_w, WUE, and T_d to prolonged drought in AP and SP under sandy and loamy soils in the Liudaogou watershed on the northern Loess Plateau. Our objectives are to: (i) determine how physiological parameters respond to PASWC; (ii) establish quantitative relationships between physiological parameters and PASWC through multiple regression; and (iii) quantify PASWC thresholds for both species under different soil textures. These results will help determine soil water use efficiency and provide references for rational vegetation allocation across different soil textures on the Loess Plateau.

2.1 Study Area

This study was conducted at the Shenmu Erosion and Environmental Research Station, located in the Liudaogou watershed (38°46′-38°51′N, 110°21′-110°23′E) on the northern Loess Plateau, China. This area experiences both water and wind erosion, with an average altitude of approximately 1178 m, an annual mean air temperature of 8.4°C, and mean annual precipitation of 442 mm. Precipitation is concentrated from July to September, with heavy rainfall contributing 70%-80% of the annual total. The landform consists of sheet sand-covered loess hills with large variations in soil particle composition. Soil types include sandy soil, loamy sand soil, sandy loam soil, silty loam soil, and clay loam soil, with silt being the main component. Silty loam soil covers approximately 39.3% of the total area, sandy loam soil covers 27.8%, loamy sand soil covers 16.2%, sandy soil covers 11.9%, and clay loam soil covers 4.8% [?]. Natural vegetation in the Liudaogou watershed was severely degraded, but vegetation cover has gradually improved since the conversion of farmland back to forest and grassland. Current vegetation is dominated by artificial forests, including *Prunus sibirica*, SP, AP, *Caragana microphylla*, *Medicago sativa*, *Amorpha fruticosa*, and *Imperata cylindrica* [?].

2.2 Sampling and Analysis

Undisturbed soil samples from 0–30 cm depth were collected at 10-cm intervals using stainless steel cutting rings in May 2018 to measure bulk density (BD), field capacity (FC), and saturated hydraulic conductivity (K_s). BD and FC were determined using the method of Grossman and Reinsch [?]. K_s was measured by the constant hydraulic head method [?] at 10°C. Disturbed soil samples from the same depth interval were also collected at 10-cm increments to determine soil organic carbon (SOC), soil total phosphorus (STP), soil total nitrogen (STN), and particle size distribution (PSD). SOC, STP, and STN were measured using the $K_2Cr_2O_7$ oxidation method [?], the ascorbic acid molybdenum blue method [?], and the Kjeldahl method [?], respectively. Soil particle size was determined using an MS2000 laser particle size analyzer (Malvern Instrument, Malvern, England). Clay (<0.002 mm), silt (0.002–0.020 mm), and sand (0.020–2.000 mm) fractions were classified according to the international texture classification system [?]. Basic soil properties are listed in Table 1 .

2.3 Experimental Design and Measurement

Three-year-old seedlings of AP and SP grown in the Liudaogou watershed were selected as experimental materials. Typical sandy and loamy soils from the watershed were collected, air-dried, and sieved through a 2-mm mesh. Equal weights (20 kg) of loamy and sandy soils were placed separately in metal planters (height: 50 cm; diameter: 25 cm), saturated with water, and allowed to stand for 1–2 days. Seedlings of AP and SP were then transplanted into these planters and managed regularly to maintain well-watered conditions (80% FC). After one month, seedlings of similar height (40–50 cm) and stem diameter (3–5 mm) were selected as test plants, with three plants per pot. Plants received sufficient water for one month before the experiment began (SWC maintained at 80%–100% FC) to ensure uniform survival. Pots were randomly arranged under a movable outdoor rain shelter. Four treatment combinations were established (sandy soil-AP, loamy soil-AP, sandy soil-SP, and loamy soil-SP), each with five replications. The soil surface was uniformly covered with gravel (diameter: 0.5–1.5 cm; layer thickness: 2.0 cm) to inhibit evaporation. After experiment initiation, water supply was stopped for all plants, allowing soil moisture to evaporate freely. Pots were weighed every two days until SWC decreased from 100% FC (loamy soil: 273.4 g/kg; sandy soil: 146.7 g/kg) to 90%, 80%, 60%, 40%, and 20% FC (corresponding water contents: loamy soil: 246.0, 218.7, 164.0, 109.4, and 54.7 g/kg; sandy soil: 132.1, 117.4, 88.0, 58.7, and 29.4 g/kg) during the growing season from June to August 2018.

When SWC was maintained at target levels (100%, 90%, 80%, 60%, 40%, and 20% FC) for 3–5 days by weighing and adding water as needed, physiological parameters (P_n, G_s, C_i, ψ_w, WUE, and T_d) of AP and SP seedlings were measured hourly from 08:00 to 18:00 (local standard time). During measurement periods, water was added as necessary to ensure SWC remained stable at each stage, allowing plants to fully acclimate before physiological measurements. Parameters were measured using a handheld photosynthesis system (LI-6400, LI-COR Inc., Nebraska, USA) for P_n, G_s, C_i, WUE, and T_d, and a water potential instrument (Model PSYPRO, Wescor Corp., Logan, UT, USA) for ψ_w. For ψ_w measurement, 6-mm diameter leaf discs were cut from three plants, sealed in C-52 sample chambers, equilibrated for 30 minutes, and recorded using a Wescor HR-33T microvoltmeter in psychrometric mode.

2.4 Data Analysis

Potted plants were weighed every two days using a high-sensitivity electronic scale (precision: 1 g). SWC reduction was calculated from weight differences relative to initial values. Cumulative daily transpiration rate (T_c) was calculated for each treatment based on water balance. Previous studies have used piecewise linear and nonlinear continuous functions to describe relationships between plant physiological parameters and SWC [?, ?, ?]. This study adopted nonlinear continuous functions to fit dynamic variation curves of soil water availability, with each curve' s inflection point representing the PASWC threshold for each parameter. Pot experiment parameters were normalized using the standard parametric equation proposed by Ray and Sinclair [?], calculated as the ratio of average observed values at different SWC treatments to the average observed values at the highest SWC treatment (100% FC). PASWC was calculated as the ratio of SWC to FC ($PASWC = SWC/FC$) following Yan et al. [?]. Data analyses were performed using SPSS 24.0, and figures were plotted using Origin Pro 9.0.

3.1 Relationships Between Physiological Parameters and PASWC

Table 2 shows quantitative relationships between physiological parameters (P_n, G_s, C_i, WUE, and T_d) and PASWC for both species in different soil textures. Seedlings of AP and SP grown in different soil textures exhibited varying PASWC thresholds for different physiological parameters. Nonlinear continuous functions effectively simulated dynamic variation characteristics of plant physiological parameters under different PASWC levels, with R^2 ranging from 0.89 to 0.99 ($P < 0.001$; Table 2).

3.2 Responses of Gas Exchange Parameters to Drought Stress in Different Soil Textures

Figure 1 [Figure 1: see original paper] illustrates dynamic variation characteristics of P_n, G_s, and C_i for AP and SP in loamy and sandy soils. As PASWC decreased, P_n and G_s of both species showed similar trends across soil textures, remaining approximately constant above certain thresholds but declining rapidly when PASWC fell below these thresholds. However, AP and SP exhibited different rates of decline and different PASWC thresholds in different soil textures (Table 2; Fig. 1). The PASWC thresholds for P_n and G_s of AP in loamy soil were 0.61 and 0.62, respectively, lower than those in sandy soil (0.70 and 0.63). In contrast, PASWC thresholds for P_n and G_s of SP in loamy soil (0.63 and 0.68) were higher than those in sandy soil (0.58 and 0.62). The C_i of both species increased with decreasing PASWC, showing trends opposite to those of P_n and G_s (Fig. 1). The PASWC threshold for C_i of AP in loamy soil (0.70) was lower than in sandy soil (0.75), while the threshold for C_i of SP in loamy soil (0.78) was higher than in sandy soil (0.66).

3.3 Responses of WUE and ψ_w to Drought Stress in Different Soil Textures

Figure 2 [Figure 2: see original paper] shows dynamic changes in WUE and ψ_w with drought stress for AP and SP in loamy and sandy soils. WUE of both species remained relatively stable when PASWC was above a threshold but decreased rapidly when PASWC fell below it. The PASWC thresholds for WUE of AP and SP in loamy soil (0.58 and 0.60) were higher than those in sandy soil (0.52 and 0.56) (Table 2). The ψ_w of both species decreased linearly with increasing PASWC across soil textures (Fig. 2).

3.4 Responses of Plant Transpiration to Drought Stress in Different Soil Textures

Figure 3 [Figure 3: see original paper] illustrates dynamic variation characteristics of T_d and T_c for AP and SP under drought stress in loamy and sandy soils. The T_d of both species remained relatively stable when PASWC was above threshold values but decreased rapidly when PASWC fell below them. The PASWC thresholds for T_d of AP and SP in loamy soil (0.60 and 0.62) were higher than those in sandy soil (0.58 and 0.55) (Table 2). Additionally, PASWC thresholds for T_c of both species in loamy and sandy soils (0.42-0.48) were lower than corresponding thresholds for T_d (0.55-0.62) (Fig. 3).

4 Discussion

In arid and semi-arid regions, soil moisture is a key factor limiting plant growth and ecosystem evolution. Even in humid and semi-humid regions, plant species commonly experience drought stress during dry seasons [?]. During the growing season, plant roots absorb and consume substantial amounts of soil water, but consumption rates and mechanisms differ markedly among species. Furthermore, different plant species and physiological parameters show different PASWC thresholds due to variations in phenological timing and environmental conditions. Consequently, more accurate evaluation of PASWC thresholds for different plants under varying soil conditions is urgently needed [?, ?, ?]. Previous studies have shown that both leaf water status and gas exchange can serve as drought indicators, though thresholds vary due to differences in species, experimental conditions, and evaluation methods [?, ?, ?, ?, ?]. However, our results indicate that ψ_w is not a suitable indicator for reflecting PASWC thresholds. One possible reason is that PASWC did not decline sufficiently to cause threshold changes in ψ_w due to the relatively high drought tolerance of AP and SP. Additionally, the small leaves of both species may affect the ability of ψ_w to exhibit threshold changes, requiring further verification with other plant species having larger leaves.

Studying PASWC for different plant species on the Loess Plateau is essential for sustainable vegetation restoration given limited soil water resources. However, in situ investigation of physiological responses to natural soil drought is difficult due to spatial heterogeneity in soil texture, climatic conditions, and vegetation types [?]. This study used pot experiments to examine dynamic changes in physiological parameters of AP and SP in different soil textures during prolonged drought and their PASWC thresholds. Results showed that physiological parameters (P_n, G_s, WUE, and T_d) of both species remained relatively constant at the beginning of soil water deficit but declined rapidly when PASWC fell below threshold values in both loamy and sandy soils (Figs. 1-3). Quantitative relationships between physiological parameters and PASWC were well modeled by nonlinear equations, with R^2 ranging from 0.89 to 0.99 ($P < 0.001$; Table 2). Significant correlations between physiological parameters and PASWC have been reported in other studies [?, ?, ?, ?]. PASWC thresholds varied among physiological parameters of AP and SP due to differences in phenological timing and soil characteristics. For instance, thresholds for instantaneous gas exchange parameters (P_n and G_s) at the transient scale were higher than thresholds at the daily scale (T_d) (Table 2), indicating that gas exchange parameters are more sensitive to soil water deficit [?]. Gas exchange responses are therefore commonly used to determine drought severity. In sandy soil, PASWC thresholds for P_n, G_s, C_i, and T_d of AP (0.70, 0.63, 0.75, and 0.58) were higher than those of SP (0.58, 0.62, 0.66, and 0.55). In contrast, thresholds for these parameters in loamy soil were lower for AP (0.61, 0.62, 0.70, and 0.60) than for SP (0.63, 0.68, 0.78, and 0.62). These interspecific differences in both soil types may be attributed to different root structures and distributions, requiring further investigation. Many studies have demonstrated different response thresholds of gas exchange parameters among plant species [?, ?] and under different experimental conditions [?, ?]. Stomatal closure is well established as the mechanism driving declines in plant transpiration and photosynthesis under mild to moderate drought [?, ?].

Our study also demonstrated that PASWC thresholds for AP and SP are affected by soil texture. Thresholds for P_n, G_s, and C_i of AP in loamy soil (0.61, 0.62, and 0.70) were lower than in sandy soil (0.70, 0.63, and 0.75), whereas thresholds for these parameters in SP were higher in loamy soil (0.63, 0.68, and 0.78) than in sandy soil (0.58, 0.62, and 0.66). Additionally, thresholds for T_d and WUE of both species were higher in loamy soil than in sandy soil. These differences may be attributed to variations in soil hydraulic properties (Fig. 4 [Figure 4: see original paper]), as sandy soil has much higher hydraulic conductivity than loamy soil (Table 1). Saliendra and Meinzer [?] showed that declining soil hydraulic conductivity can cause reductions in G_s, while Su et al. [?] found that soil texture controls vegetation growth and biomass in arid desert grassland. Thus, soil texture is a key factor controlling plant response to soil water deficit. Considering variations in physiological parameters and PASWC thresholds of AP and SP in loamy and sandy soils under prolonged drought, we recommend planting AP in sandy soil and SP in loamy soil on the Loess Plateau.

5 Conclusions

A pot experiment was designed to investigate physiological responses of AP and SP to prolonged drought in two soil textures on the Loess Plateau. Results showed that P_n, G_s, WUE, and T_d of both species remained relatively constant at the beginning of soil water deficit but decreased rapidly as PASWC fell below threshold values in both sandy and loamy soils. Different plant species and physiological parameters exhibited different PASWC thresholds, which were affected by soil texture. Based on variations in physiological parameters and PASWC thresholds of AP and SP in loamy and sandy soils under prolonged drought, we recommend planting AP in sandy soil and SP in loamy soil on the Loess Plateau.

One limitation of this study is that pot size may have inhibited plant growth due to limited space, requiring caution when extrapolating results to natural field conditions. Future research should include: (i) longitudinal and latitudinal designs to examine relationships and mechanisms between plant physiological parameters and soil water conditions at larger spatial scales; (ii) inclusion of plants at different growth stages, as seedlings may respond differently to water stress than mature plants; and (iii) development of quantitative models for predicting PASWC threshold changes in typical arbor trees, shrubs, and grasses.

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References

Allen C D, Macalady A K, Chenchouni H, et al. 2010. A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. *Forest Ecology and Management*, 259(4): 660–684.

Belko N, Zaman-Allah M, Cisse N, et al. 2012. Lower soil moisture threshold for transpiration decline under water deficit correlates with lower canopy conductance and higher transpiration efficiency in drought-tolerant cowpea. *Functional Plant Biology*, 39(4): 306–322.

Bielorai H. 1973. Prediction of irrigation needs. In: Yaron B, Danfors E, Vaadia Y. *Arid Zone Irrigation*. Berlin: Springer, 359–365.

Blackman C J, Brodribb T J, Jordan G J. 2009. Leaf hydraulics and drought stress: response, recovery and survivorship in four woody temperate plant species. *Plant, Cell & Environment*, 32(11): 1584–1595.

Bremner J M, Tabatabai M A. 2008. Use of an ammonia electrode for determination of ammonium in Kjeldahl analysis of soils. *Communications in Soil Science and Plant Analysis*, 3(2): 159–165.

Breshears D D, Cobb N S, Rich P M, et al. 2005. Regional vegetation die-off in response to global-change-type drought. *Proceedings of the National Academy of Sciences of the United States of America*, 102(42): 15144–15148.

Bresson J, Vasseur F, Dauzat M, et al. 2015. Quantifying spatial heterogeneity of chlorophyll fluorescence during plant growth and in response to water stress. *Plant Methods*, 11: 23, doi: 10.1186/s13007-015-0067-5.

Casadebaig P, Debaeke P, Lecoeur J. 2008. Thresholds for leaf expansion and transpiration response to soil water deficit in a range of sunflower genotypes. *European Journal of Agronomy*, 28(4): 646–654.

Dai A. 2011. Drought under global warming: A review. *WIREs Climate Change*, 2(1): 45–46.

Gallé A, Haldimann P, Feller U. 2007. Photosynthetic performance and water relations in young pubescent oak (*Quercus pubescens*) trees during drought stress and recovery. *New Phytologist*, 174(4): 799–810.

Grossman R B, Reinsch T G. 2002. Bulk density and linear extensibility. In: Dane J H, Clarke Topp G. *Methods of Soil Analysis: Part 4 Physical Methods*. Madison: Soil Science Society of America, 201–228.

Guo Q R, Li Y S. 1994. Soil moisture availability to plant in the southern the Loess Plateau. *Acta Pedologica Sinica*, 31(3): 236–243. (in Chinese)

Huang L M, Shao M A. 2019. Advances and perspectives on soil water research in China' s Loess Plateau. *Earth-Science Reviews*, 199: 102962, doi: 10.1016/j.earscirev.2019.102962.

Huxman T E, Smith M D, Fay P A, et al. 2004. Convergence across biomes to a common rain-use efficiency. *Nature*, 429(6992): 651-654.

Jia X X, Shao M A, Zhang C C, et al. 2015. Regional temporal persistence of dried soil layer along south-north transect of the Loess Plateau, China. *Journal of Hydrology*, 528: 152-160.

Jury W A, Horton R. 2004. *Soil Physics* (6th ed.). New Jersey: John Wiley & Sons, Inc., 78-83.

Lagergren F, Lindroth A. 2002. Transpiration response to soil moisture in pine and spruce trees in Sweden. *Agricultural and Forest Meteorology*, 112(2): 67-85.

Mao N, Huang L M, Shao M A. 2018. Vertical distribution of soil organic and inorganic carbon under different vegetation covers in two toposequences of Liudaogou watershed on the Loess Plateau, China. *Journal of Soil and Water Conservation*, 73(4): 434-441.

Marengo J A, Espinoza J C. 2016. Extreme seasonal droughts and floods in Amazonia: causes, trends and impacts. *International Journal of Climatology*, 36(3): 1033-1050.

Medrano H, Escalona J M, Bota J, et al. 2002. Regulation of photosynthesis of C3 plants in response to progressive drought: stomatal conductance as a reference parameter. *Annals of Botany*, 89: 895-905.

Murphy J, Riley J P. 1962. A modified single solution method for the determination of phosphate in natural waters. *Analytica Chimica Acta*, 27: 31-36.

Nelson D W, Sommers L E. 1996. Total carbon, organic carbon, and organic matter. In: Sparks D L, Page A L, Helmke P A, et al. *Methods of Soil Analysis Part 3: Chemical Methods*. Madison: Soil Science Society of America, 961-1010.

Osakabe Y, Osakabe K, Shinozaki K, et al. 2014. Response of plants to water stress. *Frontiers of Plant Science*, 5: 86, doi: 10.3389/fpls.2014.00086.

Pei Y W, Huang L M, Shao M A, et al. 2020. Responses of *Amygdalus pedunculata* Pall. in sandy and loamy soils to water stress. *Journal of Arid Land*, 12(5): 791-805.

Pei Y W, Huang L M, Li D F, et al. 2021. Characteristics and controls of solute transport under different conditions of soil texture and vegetation type in the water-wind erosion crisscross region of China' s Loess Plateau. *Chemosphere*, 273: 129651, doi: 10.1016/j.chemosphere.2021.129651.

Ray J D, Sinclair T R. 1997. Stomatal closure of maize hybrids in response to drying soil. *Crop Science*, 37(3): 803-807.

Sadras V O, Milroy S P. 1996. Soil-water thresholds for the responses of leaf expansion and gas exchange: a review. *Field Crops Research*, 47(2-3): 253-266.

Saliendra N Z, Meinzer F C. 1989. Relationship between root/soil hydraulic properties and stomatal behaviour in sugarcane. *Australian Journal of Plant Physiology*, 16(3): 241–250.

Sinclair T R, Holbrook N M, Zwieniecki M A. 2005. Daily transpiration rates of woody species on drying soil. *Tree Physiology*, 25(11): 1469–1472.

Soltani A, Khooie F R, Ghassemi-Golezani K, et al. 2000. Thresholds for chickpea leaf expansion and transpiration response to soil water deficit. *Field Crops Research*, 68(3): 205–210.

Su Y Z, Wang J Q, Yang R, et al. 2015. Soil texture controls vegetation biomass and organic carbon storage in arid desert grassland in the middle of Hexi Corridor region in northwest China. *Soil Research*, 53(4): 366–376.

Ullah H, Santiago-Arenas R, Ferdous Z, et al. 2019. Improving water use efficiency, nitrogen use efficiency, and radiation use efficiency in field crops under drought stress: a review. *Advances in Agronomy*, 156: 109–157.

Viciedo D O, Prado R D M, Martinez C A, et al. 2021. Changes in soil water availability and air-temperature impact biomass allocation and C:N:P stoichiometry in different organs of *Stylosanthes capitata* Vogel. *Journal of Environmental Management*, 278: 111540, doi: 10.1016/j.jenvman.2020.111540.

Wang Y Q, Shao M A, Zhu Y J, et al. 2018. A new index to quantify dried soil layers in water-limited ecosystems: a case study on the Chinese Loess Plateau. *Geoderma*, 322: 1–11.

Wen X, Deng X Z. 2020. Current soil erosion assessment in the Loess Plateau of China: a mini-review. *Journal of Cleaner Production*, 276: 123091, doi: 10.1016/j.jclepro.2020.123091.

Wu Y Z, Huang M B. 2010. Effect of soil texture on soil water availability for different maize physiological indices. *Transactions of the Chinese Society of Agricultural Engineering*, 26(2): 82–88. (in Chinese)

Yan W M, Zhong Y Q W, Shangguan Z P. 2016. A meta-analysis of leaf gas exchange and water status responses to drought. *Scientific Reports*, 6: 20917, doi: 10.1038/srep20917.

Yan W M, Zhong Y Q W, Shangguan Z P. 2017a. Rapid response of the carbon balance strategy in *Robinia pseudoacacia*, and *Amorpha fruticosa* to recurrent drought. *Environmental and Experimental Botany*, 138: 46–56.

Yan W M, Zhong Y Q W, Shangguan Z P. 2017b. Responses of different physiological parameter thresholds to soil water availability in four plant species during prolonged drought. *Agricultural and Forest Meteorology*, 247: 311–319.

Zhang Z D, Huang M B, Yang Y N, et al. 2020. Evaluating drought-induced mortality risk for *Robinia pseudoacacia* plantations along the precipitation gradient on the Chinese Loess Plateau. *Agricultural and Forest Meteorology*, 284: 107897, doi: 10.1016/j.agrformet.2019.107897.