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EFFECTS OF WATER STRESS ON PHOTOSYNTHESIS AND BIOMASS ACCUMULATION OF KERNEL APRICOT AT SEEDING STAGE

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Key words: Kernel-Apricot, Soil Water, Photosynthesis, Chlorophyll fluorescence, Biomass

Abstract

To investigate the effects of different moisture on photosynthesis and biomass accumulation in kernel-apricot at seedling stage, the cultivar ‘Zhongren 7’ was used as the experimental material. Six water levels of T1 (15.0±0.5%), T2 (13.0±0.5%), T3 (11.0±0.5%), T4 (9.0±0.5%), T5 (7.0±0.5%) and T6 (5.0±0.5%) treatment were adopted. The results showed that the *Pn*, *Tr*, *Ci* and *Gs* gradually decreased with the water stress (WS), while the *WUE* reached the maximum at 8.0±0.5%. The diurnal variation curve of the *Pn* was unimodal indicated that there was no “noon break”. The *LSP* was gradually decreased, and the *LCP* was gradually increased, and the F_v/F_m, F_m, *ETR* and *qP* were gradually decreased with the WS, instead of the gradual increase of *qN,* the increase was reduced at the beginning at first and then gradual decrease of F_0 was found. The height, diameter, root length etc., were decreased with the WS, while the root-top ratio was increased. Therefore, the suitable soil moisture was to 9.0%-15.0%, and the optimum was to13.0% while the limit was to 5.0%.

Introduction

The photosynthesis is the important process, by which plants produce organic matter. In addition, moisture content of soil is one of the most important factors affecting photosynthesis. Existing studies have shown that drought stress not only leads to stomatal closure of plant leaves and reduction of transpiration rate, but also decreases the net photosynthetic rate of leaves (Chen *et al.* 2022). Integrated physiological and transcriptional dissection reveals that salt stress in allohexaploid wheat seedlings not only involves core genes related to nutrient transport and osmoregulatory substance biosynthesis (Pei *et al.* 2013) but also causes a gradual decrease in leaf fluorescence parameters *F0, Fv/Fm,* and *qP* (Chai *et al.* 2015, Ren *et al.* 2023). Furthermore, drought stress leads to a gradual decrease in both aboveground biomass and total plant biomass, as well as a reduction in the root-to-shoot ratio (Yan *et al.* 2011). Therefore, studying the photosynthetic physiology and biomass accumulation of plants under different drought conditions provides critical insight into plant drought responses. This knowledge offers a theoretical basis for promoting the high-yield cultivation of economic forest tree species in arid and semi-arid regions.

Apricot for kernels is a general term for plants of the genus Armeniaca whose kernels are mainly used. According to the content of amygdalin, it can be divided into two types: sweet almond and bitter almond. It is a woody oil tree species of the China. It is mainly distributed in the western arid and semi-arid areas such as Hebei, Liaoning, Gansu, Inner Mongolia, Shanxi, and Shaanxi province, known as “Pioneer Drought-resistant tree species”, it has high economic value and good ecological benefits. The apricot forests for kernels distributed in the “Three Northern Areas” of China also contain a huge carbon pool, making them one of the few eco-economic tree species suitable for cultivation in western China.

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In recent years, studies have mainly focused on the genetic diversity, transpiration, the determination of fruit nutrients, product development, flowering and fruit setting, low temperature stress and cultivation physiology of kernel apricots photosynthesis and biomass accumulation (Wei and Cui 2008). In terms of drought resistance of apricot plants, the researchers have found that under drought conditions, the number of stomata decrease, on the other hand, the transpiration rate of seedlings, leaf net photosynthetic rate, transpiration rate, stomatal conductance and ground diameter, plant height, aboveground biomass and dry weight of root increases (Ruiz *et al.* 2000, Duan *et al.* 2022). However, systematic studies on photosynthetic physiological changes, chlorophyll fluorescence characteristics and biomass accumulation in response to drought stress in almond apricot have not been reported. In this study, the biennial seedlings of the new sweet-seed apricot variety 'Zhongren 7' approved by the Research Institute of Non-timber Forestry of Chinese Academy of Forestry were used as the research object, and the experimental method of artificial water control was used to study the effect of different water conditions on photosynthesis of apricot seedlings at the seedling stage. The physiological changes and biomass accumulation as well as the mechanism of drought stress on seedling growth and development of kernel apricot were preliminarily explored to provide theoretical basis and reference for the promotion and high-yield cultivation of the new variety 'Zhongren 7'.

Materials and Methods

The experimental site is located at the experimental base of the Research Institute of Non-timber Forestry of Chinese Academy of Forestry, Jinwu Village, Yuanyang County, Henan Province (113°36′-114°15′ E, 34°55′-35°11′ N). It is located on the Northern Henan Plain, bordering the Yellow River in the south and the Yuhe Channel in the north. The terrain is high in the southwest and low in the northeast. The landform belongs to the alluvial plain of the Yellow River. The climate type is continental monsoon climate, with four distinct seasons and large temperature differences among seasons. The annual average temperature is 14.0°C, the highest temperature in July is around 26.0-29.8°C, and the lowest temperature in January is 0.1-3.9°C. The annual frost-free period is 229 days with 2,345 hrs of sunshine. The average annual rainfall is 571.7 mm with extremely uneven distribution of precipitation, about 70% of the rainfall falls in July, August, and September. The rainfall in the non-flood season is low, and the rainfall in January is usually less than 1% of the annual rainfall. The average evaporation for many years is 1599.0 mm. It is generally stronger from April to June, mostly around 200.0 mm, while the minimum is less than 100.0 mm. This area has typical site characteristics of Yellow River ancient sandy road in the central plain.

The kernel-apricot 'Zhongren 7' is bred from the offspring of *Prunus armeniaca* × *sibirica*, a sweet apricot variety crossing the largest cultivation area in China. In late November 2019, the biennial 'Zhongren 7' with consistent growth was planted in ceramic flowerpots. The soil bulk density was 1.4 g/cm^3, the organic matter content was 0.3 mg/kg, and the available P was 10.9 mg/kg. The available K was 106 mg/kg, hydrolyzed nitrogen was 56.12 mg/kg, pH was 8.52, and the maximum field moisture capacity was 18-20%. During the experiment, the flower pots was placed in a rain shelter in order to avoid the influence of rainfall. The soil moisture gradients with volumetric water content were set at 15.0±0.5% (T1, control, normal water supply, 80% of maximum field moisture capacity), 13.0±0.5% (T2) and 11.0±0.5% (T3) (mild water stress, 60-70% of maximum field water capacity), 9.0±0.5% (T4) and 7.0±0.5% (T5) (moderate water stress, 40-50% of maximum field moisture capacity), 5.0±0.5% (T6) (severe water stress, 25% of maximum field moisture capacity). Five plants per treatment were repeated three times. The soil moisture velocity measuring instrument (Zhejiang Top Instrument Co., Ltd. TZS-3X soil detector) was used and the weighing method was adopted to monitor the soil moisture content of the substrate every afternoon. When the moisture content dropped below the set water content of the treatment, water was replenished to maintain the set moisture content of each treatment.

From 24th June to 23th July, 2020, on a completely sunny day between 9:00 and 11:30 am, each pot was selected from 4 directions, east, west, south, north, to measure one piece of mature leaves in the middle and upper parts of the branches. The photosynthetic index was determined by a Li-6400 portable photosynthetic instrument (LI-COR, USA). An open-air path was used during the measurement, and the leaf chamber environmental factors controlled the leaf temperature at 25°C and the relative humidity at 50-65%. The net photosynthetic rate (*Pn*), stomatal conductance (*Cs*), transpiration rate (*Tr*) and intercellular CO_2 concentration (*Ci*) were measured under the condition of light intensity (*PAR*) of 1500 $\mu mol \cdot m^{-2} \cdot s^{-1}$. According to the formula $WUE=Pn/Tr$, the Instantaneous Water-Use Efficiency (*WUE*) was calculated through the net photosynthetic rate (*Pn*) and transpiration rate (*Tr*). The diurnal changes were measured from 6:00 am to 18:00 pm, and they were measured at 2-hrs intervals. The variation trend of *Pn* with *PAR* was determined under the conditions of light intensity (*PAR*) of 0, 20, 50, 100, 200, 400, 600, 800, 1000, 1500, 2000, 2500 $\mu mol \cdot m^{-2} \cdot s^{-1}$.

Chlorophyll fluorescence parameters were measured with a PAM-2500 portable chlorophyll fluorescence analyzer (Walz Effeltrich, Germany). The parameters include the minimum and maximum values of chlorophyll fluorescence (F_0 and F_m), PS II maximum photochemical efficiency (*Fv/Fm*), apparent photosynthetic electron transport rate (*ETR*), photochemical quenching coefficient (*qP*) and non-photochemical quenching coefficient (*qN*). Before the determination, the leaves were placed in dark place for 30 min.

After the measurement of light and physiological indicators was completed, the seedlings were carefully dug out in order to get their roots and stems respectively. The roots were put on a 0.5 mm soil sieve and rinsed with tap water, and the broken roots were collected and then the water on the surface was absorbed. Next, the root system was graded by the diameter level to measure and the length of a small part of the root system of each level, as well as weighed. The total length of root system was estimated according to the mass ratio. Subsequently, the fresh weight of the stem and root were measured respectively and put into the kraft paper bag before being put in an oven. Fixation work was done at 105°C for 8 min, then they were dried at 75°C to the constant weight. In the next step, the dry weight was weighed, and the biomass of trunks, leaves, branches, roots as well as the root-top ratio were calculated.

The experimental data was carried out in PASW Statistics 18.0, using one-way analysis of variance, and the difference between the means was analyzed with Duncan's new complex range method to compare the difference test between the data, the significance level was set at $P < 0.05$ and $P < 0.01$, and Excel 2010 was used to draw the graph.

Results and Discussion

The change of net photosynthetic rate (*Pn*) in 'Zhongren 7' at the seedling stage decreased with the aggravation of water stress, and the difference of *Pn* among the treatment was extremely significant (Fig. 1A). The *Pn* of T1 was 11.76 $\mu mol \cdot m^{-2} \cdot s^{-1}$, the highest *Pn* was in T2, which was 10.64% higher than that of T1. The *Pn* of T3, T4, T5, and T6 decreased significantly by 15.18, 20.31, 25.42 and 58.55%, respectively compared with T1. In addition, there was no significant difference between *Pn* of T3 and *Pn* of T4, as well as between the one of T4 and T5. However, the *Pn* of T3 was significantly higher than that of T5, and the reduction of *Pn* of T6 was particularly obvious (Fig. 1A).

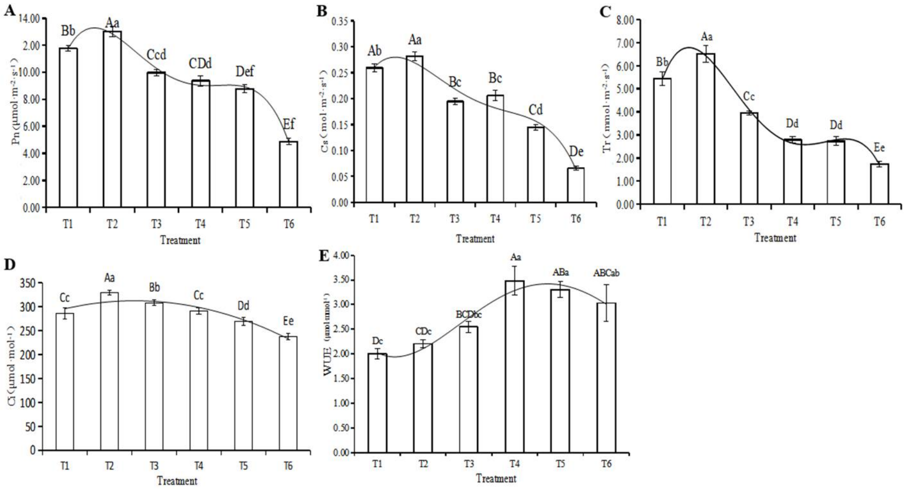

Fig. 1. Changes in *Pn, Cs, Tr, Ci* and *WUE* in the seedlings of 'Zhongren 7' under different water content treatment. (A): The net photosynthetic rate (*Pn*), (B): The transpiration rate (*Tr*), (C): Stomatal conductance (Cs), (D): The intercellular CO_2 concentration (*Ci*), and (E) Water use efficiency (*WUE*) in the seedlings of 'Zhongren 7' under different treatment. Note: Different capital and lowercase letters mean they are extremely significance ($P < 0.01$) or significance ($P < 0.05$).

With the intensification of water stress, the stomatal conductance (*Cs*) of 'Zhongren 7' decreased gradually, while it increased slightly at T4. The differences among treatments were extremely significant. The *Cs* of T2 was significantly higher than that of T1. There was no significant difference between *Cs* of T3 and T4, but both were significantly higher than that of T5 and T6. The *Cs* value of T6 was the lowest, which was 76.65% lower than that of T2 (Fig. 1B).

The transpiration rate (*Tr*) decreased sequentially with the aggravation of water stress, and the difference among treatments was extremely significant. The *Tr* of T2 was the highest at 6.51 $mmol·m^{-2}·s^{-1}$, which was 19.79% higher than that of T1. There was a significant difference between Tr of T3 and T4, but there was no significant difference between T4 and T5. T6 had the lowest *Tr* (Fig. 1C).

Ci gradually decreased with the aggravation of water stress, and the difference among the treatments reached a rather significant level. The *Ci* of T2 increased significantly by 15.01% compared with T1. The difference of *Ci* between T1 and T3 was extremely significant, while *Ci* of T1 has no difference compared with T4. The differences between *Ci* of T3 and T4 as well as T4 and T5 were both extremely remarkable. T6 has the lowest *Ci* value, which is 38.65% lower than that of T2 (Fig. 1D).

With the intensification of water stress, *WUE* value first decreased and then increased, and the difference among treatments was highly significant. The *WUE* of T1 was the lowest. The difference between T2 and T3 was not significant. The *WUE* value of T4 treatment was the highest, which was 70.97% higher than that of T1. The difference between T4 and T1 was remarkable. There was no significant difference between *WUE* value of T5 and T6, and their values of *WUE* were always higher than that of T1 (Fig. 1E).

The diurnal variation of *Pn* in 'Zhongren 7' under different water stress showed an obvious single-peak pattern, and there was no photosynthetic "noon break" phenomenon. The peak of T2 appeared at 12:00 with the value of 10.82 $\mu mol\ m^{-2}\ s^{-1}$, which was 20.06% higher than that of T1, while the *Pn* value of T2 was lower than that of T1 before 10:00 am and after 14:00 pm. The peaks of T3, T4, and T5 appeared at 10:00 am, and the peak values were 10.82, 9.56, and 7.22 µmol·m^{-2}·s^{-1}, respectively. Compared with T1, the peak value of T3 and T4 increased by 22.09 and 11.24%, respectively. The peak values appeared at 8:00 for T6, and its *Pn* value was lower than other treatments at different times (Fig. 2A).

The diurnal trend of *Tr* was unimodal. T1, T2, T3, T4, and T5 rose rapidly from 8:00 to 12:00, and reached the peak values of 7.10, 5.45, 4.42, and 5.08 mmol·m^{-2}·s^{-1},respectively, while T6 reached the peak value of 1.92 mmol·m^{-2}·s^{-1} at 10:00 am. After 12:00 pm, the *Tr* values of each treatment showed a slow downward trend. Compared with T1, the *Tr* value of T2 was greater during the day, while the values of other four treatments were lower than T1 (Fig. 2B).

The diurnal variation trend of *Cs* showed a single-peak type. The peaks of *Cs* of T1, T2 and T3 all appeared at 12:00 pm, and the peak values were 0.1837, 0.2426 and 0.1808 mmol·m^{-2}·s^{-1}, respectively. The peak values of T4, T5 and T6 appeared at 8:00 am at 0.2088, 0.1815 and 0.0875 mmol·m^{-2}·s^{-1} (Fig. 2C).

The daily change of *Ci* is a concave curve, which is basically opposite to the diurnal trend of *Pn*. The values at 6:00 am and 18:00 pm were comparatively high, and there was a valley value at 12:00 pm. The overall diurnal change of *Ci* basically shows that T2 >T4>T5>T1>T3>T6, which is basically consistent with the change of C*s* (Fig. 2A, 2C and 2D). The diurnal variation of *WUE* is obviously different from that of *Pn* and *Tr*. The *WUE* of T5 and T6 is relatively high in a day, with peaking at 8:00. The *WUE* of other treatments gradually reduced from 6:00 to 18:00 (Fig. 2B and 2E).

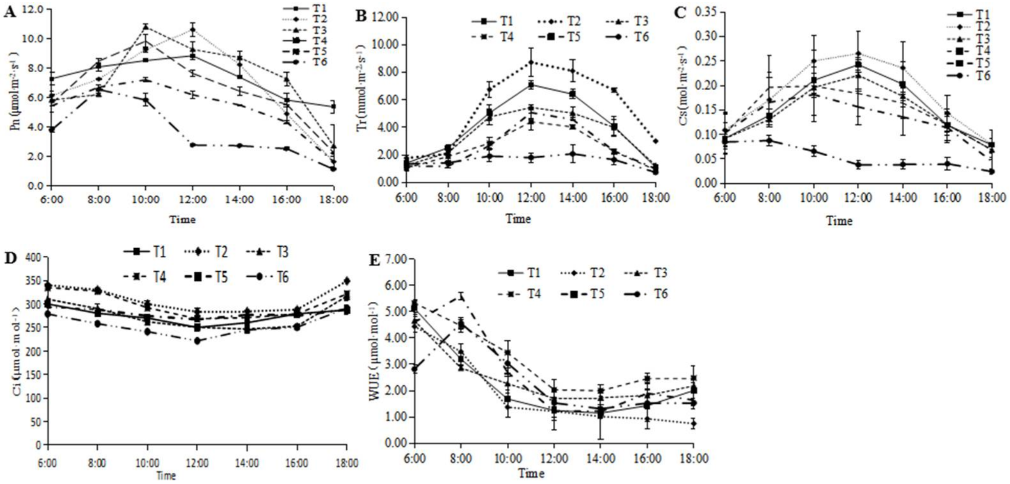

Fig. 2. Diurnal changes in *Pn*, *Cs*, *Tr*, *Ci* and *WUE* in the seedlings of ‘Zhongren 7’ under different water treatment.

The variation tendency of the *Pn-PAR* light response curves under different treatments was basically the same, with an obvious light saturation point, which means that the net photosynthetic rate increased at first and then became stable with the increase of light intensity. As the water stress intensified, the Light Saturation Point (*LSP*) of ‘Zhongren 7’ gradually declined while the Light Compensation Point (*LCP*) gradually rose. The maximum Photosynthetic rate (P_{nmax}) also descended. As the soil moisture content was controlled as the same of T1, T2 and T3, the light saturation point (*LSP*) and maximum Photosynthetic rate (P_{nmax}) of ‘Zhongren 1’ were relatively high, while the values of *LSP* and P_{nmax} of T4, T5, and T6 were relatively low (Fig. 3).

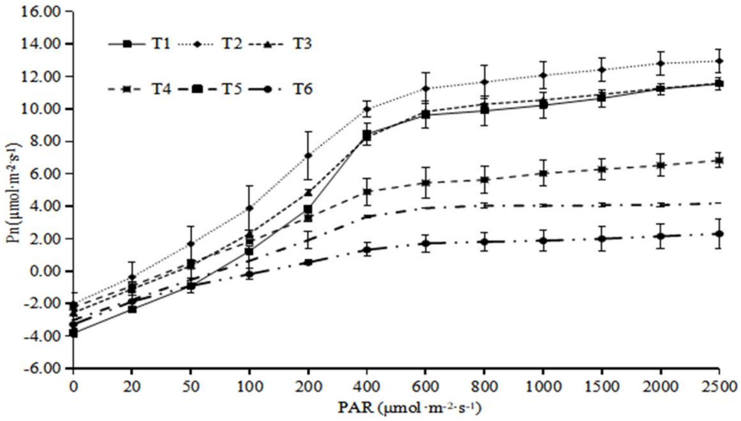

Fig. 3. Net photosynthetic rate on the response of photosynthetic active radiation (PAR) of the seedlings 'Zhongren 7' under different water content treatment.

Fv/Fm is the maximum photochemical quantum yield of PSⅡ and the parameter changes very little and is not affected by species and growth conditions under non-stress conditions. Under stress conditions, this parameter decreases significantly. There was no significant difference among the *Fv/Fm* of T1, T2, T3, and T4, and the values were all around 0.80. There was also no significant difference between T5 and T6, but the values of T1, T2, T3 and T4 were all remarkably lower than that of T5 and T6 (Fig. 4A).

qP reflects the share of photochemical electron transfer in the luminous energy absorbed by the pigment of PSⅡ antenna. To maintain high photochemical quenching, the PSⅡ reaction center must be in an "open" state. Therefore, photochemical quenching reflects the openness of the PSⅡ reaction center to some extent. The degree of openness of the reaction center. *qP* was significantly different among different treatments, and the value of *qP* decreased gradually with the aggravation of stress. The value of *qP* of T2 was significantly higher than the other 5 treatments, and there was no significant difference between T1 and T3. The difference among T4, T5 and T6 was also remarkable (Fig. 4B).

qN reflects the portion of luminous energy absorbed by PSⅡ antenna pigments that is not used for photosynthetic electron transfer but dissipated in the form of heat (Maxwell and Johnson 2000). Then difference of *qN* under different water treatments was extremely significant, and with the decrease of soil moisture content, *qN* showed a gradual upward trend. It reached the maximum at T6, which has extremely significant difference with T1. The difference between T1 and T2 was not significant, while the difference between T3, T4, and T5 was extremely significant. The difference between T5 and T6 was not significant (Fig. 4C).

Fo is the fluorescence yield when the PSII reaction center is fully open (Maxwell and Johnson 2000). With the increase of drought stress, *Fo* generally showed a trend of "increasing first and then decreasing", and the difference of *Fo* among different treatments reached a very significant level. Multiple comparisons made by the new multiple range test showed that there were no significant changes among T1, T2 and T3, T2, T3 and T4, as well as T3, T4 and T6. The difference between *Fo* of T5 and T2 was extremely significant (Fig. 4D).

Fm is the fluorescence yield when the PSII reaction center is completely closed, reflecting the electron transfer through PSII (Guo *et al.* 2008). The difference of *Fm* under different water treatments was extremely significant, and the value of *Fm* decreased sequentially with the decrease of moisture content of soil. The *Fm* values of T1, T3, T4 and T5 were not significantly different, and the *Fm* value of T2 was the largest, with no significant different with T3. The *Fm* value of T6 was the smallest, which was significantly lower than the other five treatments (Fig. 4E).

The difference of *ETR* under different moisture treatments was extremely significant. It showed a decreasing trend as the moisture decreased in a gradient. The difference between T1 and T2 was not significant, but the difference of *ETR* among T3, T4, T5 and T6 was extremely significant (Fig. 4F).

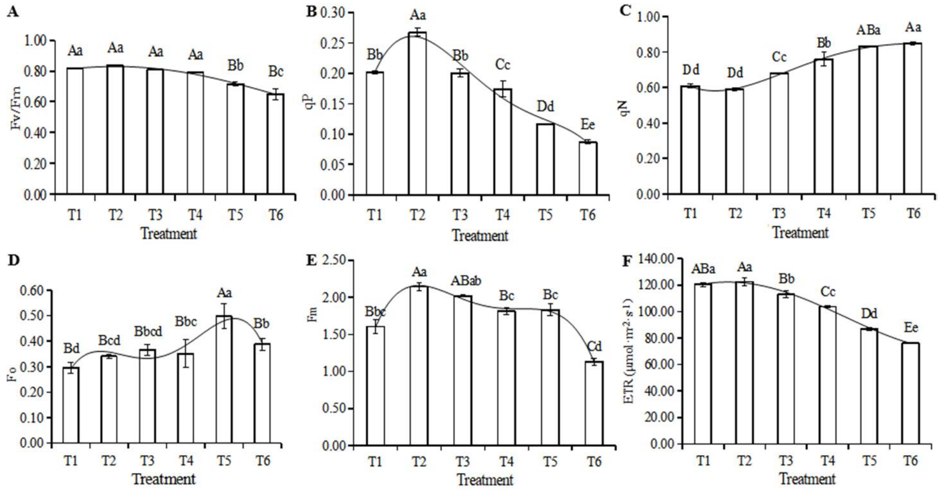

Fig. 4. Change in Fv/Fm, qP, qN, Fo, Fm and ETR in the seedlings of 'Zhongren 7' under different water content treatment.(A): Fv/Fm (PSII maximum quantum yield), (B): qP (photochemical quenching coefficient), (C): qN (nonphotochemical quenching coefficient), (D): Fo (minimal fluorescence), (E): Fm (maximum fluorescence), and (F): ETR in the seedlings of 'Zhongren 7' under different treatment.

In terms of growth indicators, there were significant differences in clear length, plant height, ground diameter, taproot length, and total root length of 'Zhongren 7' among different treatments. Each index showed a gradual reduction with the aggravation of water stress. The analysis of variance showed that there was no significant difference in the clear length among the treatments. The difference between the plant heights was insignificant, but there was a significant difference between plant height of T2 and T6. In terms of the ground diameter, the value of T2 was significantly higher than the other four treatments with different stress, but the difference with T1 was not significant. The variation trend of taproot length and total root length was similar to the one of ground diameter, and the overall trend was T2 > T1>T3>T4>T5>T6 (Fig. 5).

In terms of biomass distribution, there were significant differences in dry weight of root, leaves, trunk, as well as branch, and total biomass among the treatments. They all showed a gradual decline with the aggravation of drought stress, and each index had the optimal growth change under mild drought stress (T2). From the dry weight of leaves, the value of T2 was significantly higher than other treatments, and it has no significant difference between T1 and T3. There was no significant difference in dry weight of trunk among T1, T2 and T3, but they were all extremely significantly higher than T4, T5, and T6. In terms of dry weight of branch, T2 was extremely significantly higher than other treatments and controls. There was no significant difference between dry weight of branch of T1 and T3, while they were all extremely significantly higher than T4, T5, and T6. Among T4, T5 and T6, there was no significant difference in dry weight of branch. In terms of total biomass, the treatments differ significantly from each other. In addition, differences in the root-top ratio among the treatments were also significant. The ratio showed the trend of increasing gradually with the aggravation of drought stress, and the ratio of T2 was significantly lower than other treatments (Fig. 5).

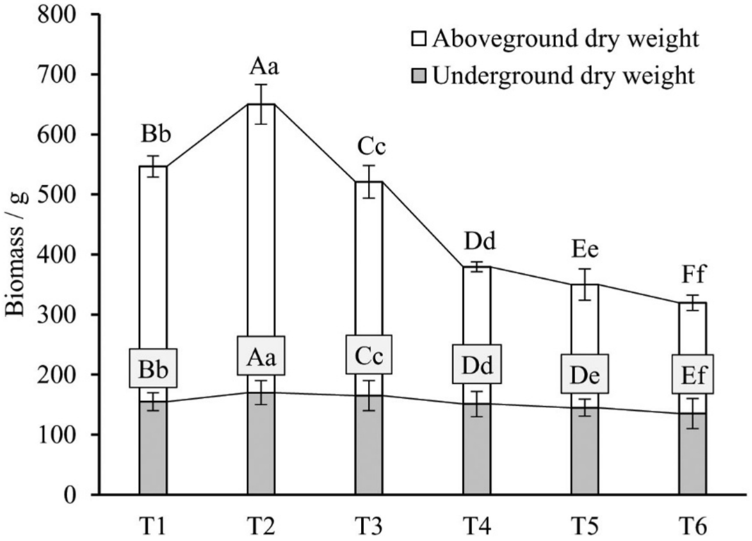

Fig. 5. Variations in biomass accumulation of 'Zhongren 7'with different soil water contents.

According to Farquhar et al. (1982), if the decrease in net photosynthetic rate is accompanied by a decrease in stomatal conductance and intercellular CO_2 concentration, the main reason for the decrease in net photosynthetic rate is stomatal factors. In this study, it was found that the *Pn* of 'Zhongren 7' decreased significantly, and C*s* and *Ci* also decreased significantly with the intensification of water stress from observing the variation values of *Pn*, C*s*, *Ci* and *Tr* with water stress and the change rule of diurnal variation (Fig. 1 and 2). It indicated that stomatal factors were one of the main reasons for the decline in photosynthetic rate of 'Zhongren 7', which was also found in mulberry (*Morus alba*) and citrus. Compared with T1, each photosynthetic index was higher in varying degrees under mild water stress (T2), indicating that certain water stress (13.0%) stimulated the photosynthesis of 'Zhongren 7' seedlings (Huang *et al.* 2012, Zhou *et al.* 2021). At the same time, when the seedlings of 'Zhongren 7' were subjected to certain water stress (7.0-11.0%), although *Pn* decreased, water dissipation is reduced by lowering *Tr* and *WUE* was increased to enhance its drought resistance, which was similar to that of *Eleutherococcus senticosu* seedlings under drought stress (Song *et al.* 2007). The diurnal variation of *Pn* in 'Zhongren 7' showed a typical unimodal curve (Fig. 2), indicating that 'Zhongren 7' is a tree species that does not take a "noon break" in the growing season and grows at full speed. This phenomenon is different from that of the diurnal variation of *Pn* in 'Jinguang' apricot plum changed from bimodal pattern to unimodal pattern when it was subjected to moisture stress as well as the bimodal curve of *Pn* in *Cerasus humilis* under water stress (Liu *et al.* 2007). It may be due to the different drought resistance of the plants. With the intensification of water stress, the *LSP* of each treatment gradually decreased. The gradual increase of *LCP* indicated that the range of light adaption of

'Zhongren 7' seedlings became smaller and smaller (Fig. 3), which was also one of the main reasons for the decrease of *Pn*.

Changes in photosynthesis cause corresponding changes in fluorescence emission, so fluorescence changes can reflect the situation of photosynthesis and heat dissipation. In chlorophyll fluorescence, *Fv/Fm* reflects the efficiency of the open PS II reaction center to capture excitation energy, and it is an important parameter to study plant stress. Any environmental stress that affects PS II performance will reduce the value of *Fv/Fm* (Dai *et al.* 2022). This study shows that under the condition of mild water stress (T2), *Fv/Fm* has a slight increase compared with T1. With the aggravation of water stress, *Fv/Fm* gradually decreases, indicating that the aggravation of water stress could damage PS II. Under the condition of water stress, the *Fm* of 'Zhongren 7' gradually decreased, and the *Fo* gradually increased (Fig. 4), indicating that among the energy absorbed by pigment, the energy lost in the form of heat and fluorescence increased, while the energy used for photosynthesis decreased significantly, which corresponded to the decrease of *Pn*. At the same time, severe water stress also caused a decrease in *qP* and *ETR*, and an increase in *qN* (Fig. 4), demonstrating that drought could hinder the photosynthetic electron transport and increase the amount of luminous energy dissipated in the form of heat.

Suitable soil moisture content can promote plant growth, and dry soil makes it difficult for roots to absorb water and make plant cells lack water, thereby inhibiting their division and growth (Guo *et al.* 2020). The study has found that each growth index and biomass index of 'Zhongren 7' seedlings gradually decreased with the intensification of water stress (Fig. 5), indicating that water stress has certain inhibitory effect on the growth of seedlings; especially under severe water stress condition (T6). In T6, each index was the lowest among the treatments, demonstrating that water had a significant inhibitory effect on the growth of seedlings. In addition, the values of each index of T2 were higher than that of the control group T1, indicating that mild water stress could promote the growth of 'Zhongren 7' seedlings to some extent (Fig. 5). The finding is consistent with the performance of photosynthesis and fluorescence, which may be the response to water stress of the plant. This is similar with the results of study of Yan *et al.* (2011) on Tiaodunsang, while their study did not find that the changes of the indexes were higher than those of the control group under mild water stress. Moreover, the root-top ratio gradually increased with the intensification of water stress, indicating that 'Zhongren 7' would initiate a self-adjustment mechanism under drought conditions, transferring photosynthetic products to the underground part to enhance its adaptability to adversity, which is in line with the phenomenon of "To grow roots in drought and to grow seedlings in wet".

In summary, 'Zhongren 7' can cope with drought stress through self-growth regulations such as improving water-use efficiency, increasing light compensation point and root-top ratio at the seedling stage. It maintained high photosynthetic efficiency and high capability of biomass accumulation, and improved its drought resistance ability with no "noon-break" at the growing season. The optimal soil moisture content for its growth was 13.0%, and the photosynthesis and growth of kernel apricot was not affected greatly within the range of 9.0-15.0%. In addition, since the root distribution of 'Zhongren 7' was shallow at the seedling stage, it was necessary to prevent the damage to the plant caused by the soil moisture content below 5.0% during the growing season.

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