

Effect of salt-alkali stress on the growth and photosynthetic properties of two *Prunus mume* species

Anqi Ren¹, Yanan Cai², Qingwei Li^{1,*}

¹ School of Landscape Architecture, Beijing Forestry University Beijing, China

² Dezhou Landscape Service Center Shandong, China

* Corresponding Author Email: lqw6809@bjfu.edu.cn

Abstract. [Objective] To investigate the salt resistance growth status and photosynthetic characteristics of *Prunus mume* and saline-alkaline resistance of different *Prunus mume* varieties against mixed salt stress, aiming to provide scientific basis for the application of *Prunus mume* in saline-alkali land. [Methods]. Taking the *Prunus mume* 'ZaohuaLve' and *Prunus mume* 'Meiren' under two years of cutting seedlings as examples, NaCl and NaHCO₃ were prepared into treatment solution at a molar mass ratio of 1:1, with six gradients (i.e., 0 (CK), 100 (S1), 200 (S2), 300 (S3), 400 (S4) and 500 (S5) mmol L⁻¹) to observe the growth status and photosynthetic reaction of test plants under different salt concentrations. [Results] With the increase of salt treatment concentration and stress time, the growth amount of leaf length, leaf width and ground diameter of the two kinds of *Prunus mume* decreased, and the *Prunus mume* 'ZaohuaLve' salt tolerance threshold (330.189 mmol L⁻¹) is greater than *Prunus mume* 'Meiren' (292.453 mmol L⁻¹). On the other hand, the chlorophyll content of the two *Prunus mume* increased first and then decreased, and the maximum, actual quantum yield of PS II and photochemical quenching coefficient decreased as a whole. The net photosynthetic rate (Pn), stomatal conductance (Gs), and transpiration rate (Tr) of the two *Prunus mume*s decreased overall. For the *Prunus mume* 'ZaohuaLve', Ci values increased at 0 - 10d, and the changes were inconsistent in Pn, Gs and Ci at later stages of salt stress. The overall trends in the Pn, Ci, and Gs values of *Prunus mume* 'Meiren' were consistent for the 100 and 200mmol L⁻¹ treatments. [Conclusion] The growth index and photosynthetic index of the two *Prunus mume*s in the early stage of salt stress are not obvious with salt tolerance. The *Prunus mume* 'Meiren' salt stress was dominated by stomatal restriction in the early stage, while non-stomatal restriction was the main factor affecting photosynthesis in the later stage. By contrast, the two factors may coexist simultaneously in the *Prunus mume* 'Meiren'. Overall, the *Prunus mume* 'ZaohuaLve' was stronger than *Prunus mume* 'Meiren' regarding the saline-alkaline resistance.

Keywords: *Prunus mume*; mixed salt stress; apparent characteristics; photosynthetic characteristics.

1. Introduction

Salt stress can be divided into neutral salt stress, alkaline salt stress and mixed salt stress [1]. NaCl is principal cause of neutral salt stress and NaHCO₃ is principal cause of alkaline salt stress. Soil salinization causes low plant coverage rate and single plant species, which seriously restricts the sustainable development of urban environment. In recent years, China has been committed to the research of plant salt tolerance. The increased soil salt will reduce the ability of plants to absorb water, weaken the basic metabolism of plants, and affect the plant growth and development process [2]. The *Prunus mume* is a commonly used green tree species in the garden, with high ornamental value and broad application prospect. The *Prunus mume* is salinity tolerant and grows normally in the soil environment with pH 8-9 [3]. Currently, studies on *Prunus mume* salt-alkali stress are relatively limited with few research on monosaline NaCl. With the increasing concentration of NaCl, both the salt damage rate and the salt damage index of *Prunus mume* will increase, while the growth index of leaf length and width and higher plant level will decrease. Studies on the salt tolerance of *Prunus mume* seedlings showed that the salt tolerance sequence from the strong to the weak is: 'XiangxueGongfen' > 'Fenghou' > 'Meiren' [4]. Using 0.6%-0.9% salt treatment, *Prunus mume* grafted seedlings can be significantly enhanced by leaf photosynthesis compared with those of self-rooted seedlings [5].

However, the saline-alkali soil in China is in the form of mixed salt [6], and the salination and alkalization of soil appear simultaneously [7]. Soil is the synergistic effect from the mixed salt and alkali, not only a simple superposition of the two stresses. In this study, we explored the salt tolerance mechanism of *Prunus mume* 'ZaohuaLve' and *Prunus mume* 'Meiren' under mixed salt alkali treatment from the apparent characteristics and physiological biochemistry, which can lay a certain theoretical foundation for the selection and cultivation of salt-tolerant *Prunus mume*. Also, this study is of great significance to enrich the saline-alkali land landscape and improve the urban and rural environment.

2. Materials and Methods

2.1. Experimental materials

The experiment was carried out in the greenhouse of North Forest Science Park of Beijing Forestry University, with *Prunus mume* 'ZaohuaLve' and *Prunus mume* 'Meiren' as examples.

2.2. Experimental methods

2.2.1. Culture and salt stress treatment of the *Prunus mumes*

In March 2018, seedlings with consistent growth were planted in plastic pot with trays under the pelvic floor. The pot is filled with 6.0 kg matrix, which is composed of chat soil, perlite and wash river sand at a volume ratio of 2:1:1. Testing began in late June 2019. NaCl and NaHCO₃ were prepared into treatment solution at a molar mass ratio of 1:1 with six salt gradients of 0 (CK), 100 (S1), 200 (S2), 300 (S3), 400 (S4) and 500 (S5) mmol L⁻¹, with three strains for each treatment in five replicates. To prevent the salt shock effect, the salt was applied with multiple times starting from the high concentration treatment, with 700 mL of salt solution in each basin. The preset concentration is reached by gradual increasing, and the same amount of water is poured in other treatment groups to reach the preset concentration on the fifth day, which is recorded as the first day at the beginning of salt stress (with a total of 40 days).

2.2.2. Index determination method

Salt damage index and salt damage rate: after the salt treatment, counting the number and grade of salt damage plants, and calculating the salt damage index (SI) and salt damage rate (P) [8] as shown in Table I.

Table I. Phenotype changes of landscape plants under saline-alkali stress.

Salt hazard level	Morphological description
0	No salt damage symptoms
1	Mild salt damage, leaf tip, leaf margin or leaf veins in a small part of the yellow
2	Moderate salt damage, leaf tip, leaf edge nearly 1/2 coke dry
3	Severe salt damage, most of the leaf tip, leaf edge dead or fall off
4	Very severe salt damage, branches withered, leaves fall, plant death

Salt damage rate P (%) = number of salt injury symptoms / total strains 100% salt injury index.

SI (%) = (number of strains corresponding to salt damage level) / (total number of strains highest salt damage level) 100%.

Determination method of the growth index: The leaf length, leaf width and ground diameter were measured using vernier caliper with 0.01 cm, and the difference is the relative growth under stress.

Measurement of the photosynthetic parameters and chlorophyll fluorescence parameters: The upper middle functional leaves were put into the ice box every 10d before and after treatment and brought back to the laboratory for chlorophyll content determination immediately by acetone-ethanol extraction method. Net photosynthetic rate (Pn), stomatal conductivity (Gs), transpiration rate (Tr), and intercellular CO₂ concentration (Ci) were determined using a portable photosynthetic system tester LI-6400. The measurement condition is light intensity 1000 $\mu\text{mol m}^{-2}\text{s}^{-1}$. After the leaves were fully

dark adapted for 30 min, the PS maximum light energy conversion efficiency (Fv/Fm), photochemical quantum yield, photochemical quenching coefficient (qP) were measured using a portable modulated chlorophyll fluorometer PAM-2500.

2.2.3. Statistical analysis

The data processing, statistics, and mapping were performed using Excel 2019, GraphPad Prism 7.0, and SPSS 22.0 software.

3. Results and discussion

3.1. Effect of mixed salt stress on the apparent traits of the two *Prunus mume* species

3.1.1. Effect of mixed salt stress on the apparent features of the two *Prunus mume* species

After 40d of stress, the leaf change characteristics of each plant (see Fig. 1) showed that with the increase of salt concentration, the symptoms of salt damage gradually increased. Under S1 treatment, the salt damage index of *Prunus mume* 'ZaohuaLve' is 0, and *Prunus mume* 'Meiren' shows level 1 salt damage; Under S2 treatment, there began to show some salt damage in both *Prunus mumes*; Under S3 and S4 treatment, the salt damage rate of both *Prunus mumes* reached 100% and all plant leaves have fallen or died; Under S5 treatment, almost all of the plant leaves have fallen off or died.

Combining the salt damage index and salt damage rate, the mixed salt concentration at *Prunus mume* 'ZaohuaLve' and *Prunus mume* 'Meiren' is 50% (Table II) is 330.189 mmol L⁻¹ and 292.453 mmol L⁻¹, respectively. This indicates that *Prunus mume* 'ZaohuaLve' is more resistant than *Prunus mume* 'Meiren' regarding the mixed salt stress.

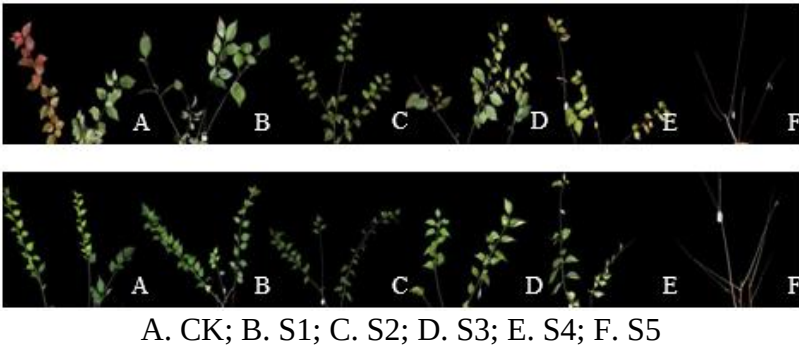


Fig 1. P Phenotypic changes of leaves of *Prunus mume* ‘ZaohuaLve’ and *Prunus mume* ‘Meiren’ under mixed salt stress.

Table II. Phenotypic trait change of prunus mume under mixed salt stress.

Botanic scientific name	Treatment	Salt stress level					Salt injury index	Salt injury rate
		0	1	2	3	4		
<i>Prunus mume</i> ‘ZaohuaLve’	CK	0	0	0	0	0	0	0
	S1	5	0	0	0	0	0	0
	S2	4	1	0	0	0	5%	20%
	S3	0	3	2	0	0	35%	100%
	S4	0	0	2	2	1	70%	100%
	S5	0	0	0	0	5	100%	100%
<i>Prunus mume</i> ‘Meiren’	CK	0	0	0	0	0	0	0
	S1	4	1	0	0	0	5%	20%
	S2	3	1	1	0	0	15%	40%
	S3	0	1	3	1	0	50%	100%
	S4	0	0	0	2	3	90%	100%
	S5	0	0	0	0	5	100%	100%

Table III. The Logistic regression equation and salt tolerance domain values (The NaCl and NaHCO₃ salt-mixed concentration of 50% Salt injury indexes) of *Prunus mume* under mixed salt stress.

Botanic scientific name	Regression equation	Regression coefficient b	Salt tolerance threshold/mmol·L ⁻¹
<i>Prunus mume</i> 'ZaohuaLve'	y=0.265x-37.500	0.265	330.189
<i>Prunus mume</i> 'Meiren'	y=0.265x-27.500	0.265	292.453

Note: X represents the concentration of mixed salt; Y represents salt damage index. Note b: Salt tolerance threshold represents the mixed salt concentration when salt injury index is 50%.

3.1.2. Effects of mixed salt stress on the growth properties of six garden plants

As is seen from Table IV, Table V, and Table VI, the growth of the two *Prunus mume* leaf lengths gradually decreased as the salt concentration increased. In terms of leaf width growth, *Prunus mume* 'ZaohuaLve' increased first and then decreased, and *Prunus mume* 'Meiren' gradually decreased; in terms of ground diameter growth, both *Prunus mume* gradually decreased.

Table IV. Effects on Leaf length increment (cm) under mixed salt stress.

Botanic scientific name	Treatment					
	CK	S1	S2	S3	S4	S5
<i>Prunus mume</i> 'ZaohuaLve'	0.90±0.10a	0.84±0.07a	0.83±0.06a	0.66±0.09b	0.60±0.04b	0.00±0.00c
<i>Prunus mume</i> 'Meiren'	0.31±0.01a	0.25±0.01ab	0.28±0.09ab	0.20±0.06b	0.19±0.03b	0.00±0.00c

Note: Different lowercase letters indicate that there is significant difference at 0.05 level among different treatments (P<0.05); Data are mean ± standard deviation, similarly hereinafter.

Table V. Effects on Leaf width increment (cm) under mixed salt stress.

Botanic scientific name	Treatment					
	CK	S1	S2	S3	S4	S5
<i>Prunus mume</i> 'ZaohuaLve'	0.38±0.04ab	0.43±0.06a	0.37±0.04abc	0.32±0.02bc	0.31±0.02c	0.00±0.00d
<i>Prunus mume</i> 'Meiren'	0.29±0.02a	0.19±0.03b	0.21±0.03bc	0.17±0.02c	0.13±0.01d	0.00±0.00e

Table VI. Effects on Diameter growth (cm) under mixed salt stress.

Botanic scientific name	Treatment					
	CK	S1	S2	S3	S4	S5
<i>Prunus mume</i> 'ZaohuaLve'	0.15±0.06a	0.15±0.06a	0.16±0.02a	0.10±0.03ab	0.09±0.05b	0.05±0.02b
<i>Prunus mume</i> 'Meiren'	0.19±0.03a	0.14±0.06ab	0.10±0.02bc	0.11±0.06bc	0.05±0.02cd	0.02±0.01d

3.2. Effect of mixed salt stress on the two *Prunus mume* photosynthetic indexes

3.2.1. Effect of mixed salt stress on photosynthetic pigments of two *Prunus mume* species

As the salt concentration increased, the chlorophyll content of *Prunus mume* 'ZaohuaLve' and *Prunus mume* 'Meiren' increased first and then decreased, reaching the maximum under S3 and S1 treatment, respectively, and decreased to the lowest at S5 high salt treatment. As shown in Fig. 2 (A), when the *Prunus mume* 'ZaohuaLve' was stressed for 20d, the chlorophyll content reached the highest value under S3 treatment, significantly increasing by 33.68% compared to the value in the 0th d. With

increasing salt concentration, the *Prunus mume* 'Meiren' chlorophyll content reached its maximum at the 20th d under S1 and S2 low salt stress. When stressed for 40d, the shedding of all leaves under S5 treatment cannot be determined as shown in Fig. 2 (B).

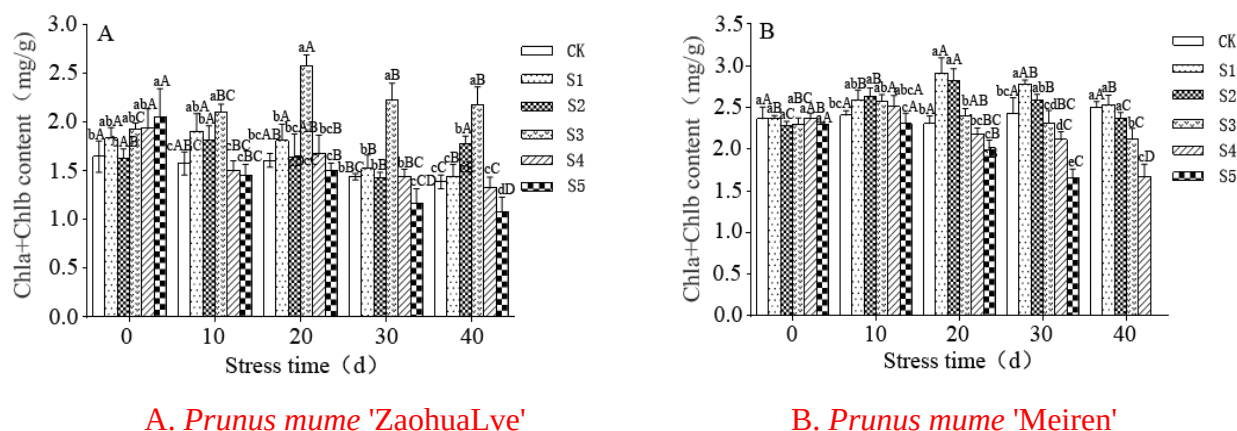


Fig 2. Effects of mixed salt on leaf chlorophyll content of the two *Prunus mume*.

Note: Different capital letters indicate significant difference at the 0.05 level between mixed salt joints at the same concentration ($P < 0.05$); Different capital letters indicate significant difference at the 0.05 level between different treatments ($P < 0.05$); Data are mean $\pm$ standard deviation, similarly hereinafter.

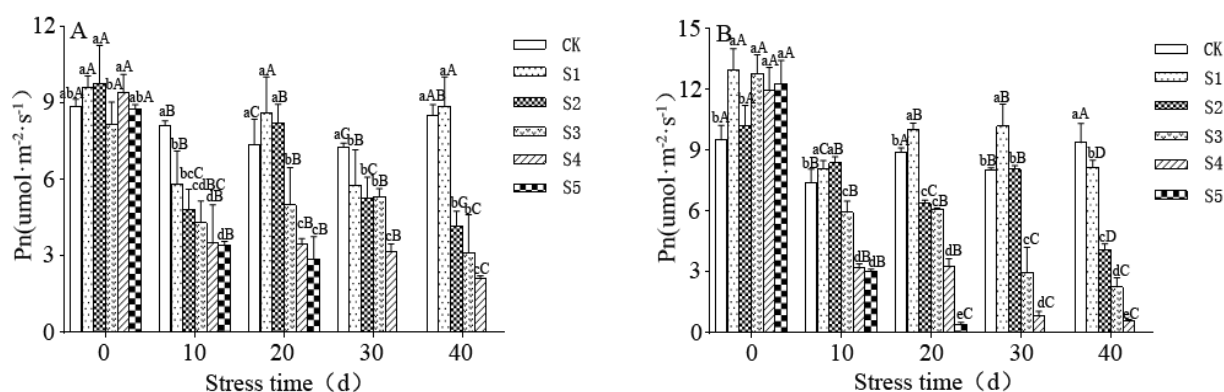
3.2.2. Effect of mixed salt stress on the two *Prunus mume* photosynthetic parameters

Fig. 3 shows that, under mixed salt stress, the P_n value in each treatment group sharply decreased, which was significantly different from CK. At 0-30d, the S1 and S2 of P_n value of *Prunus mume* 'ZaohuaLve' decreased first then rose, and S5 continuously decreased.

Fig. 4 shows that with the prolonged stress time, the G_s value of *Prunus mume* 'ZaohuaLve' decreased first and then increased and subsequently decreased under S1-S4 treatment. At 40d, photosynthesis was significantly reduced under S1-S4 treatment compared with that of 20d, but not there was no significantly difference under S1 versus CK, and plants were severely damaged at 30d. At 40d of stress, the S1-S3 treatment was significantly decreased by 23.08%, 34.62% and 88.46%, respectively.

Fig. 5 shows that with increasing salt concentration, the C_i value of *Prunus mume* 'ZaohuaLve' under S1, S3 and S4 treatment decreased first and S5 decreased at 0-30d. At 40d, under S4 treatment, it significantly decreased by 24.69% compared with 0d and 22.26% lower compared with CK. With increasing salt concentration, C_i values decreased first under *Prunus mume* 'Meiren' S1 treatment, and at 20d, C_i value was minimized with S1, S3 and S4 treatment.

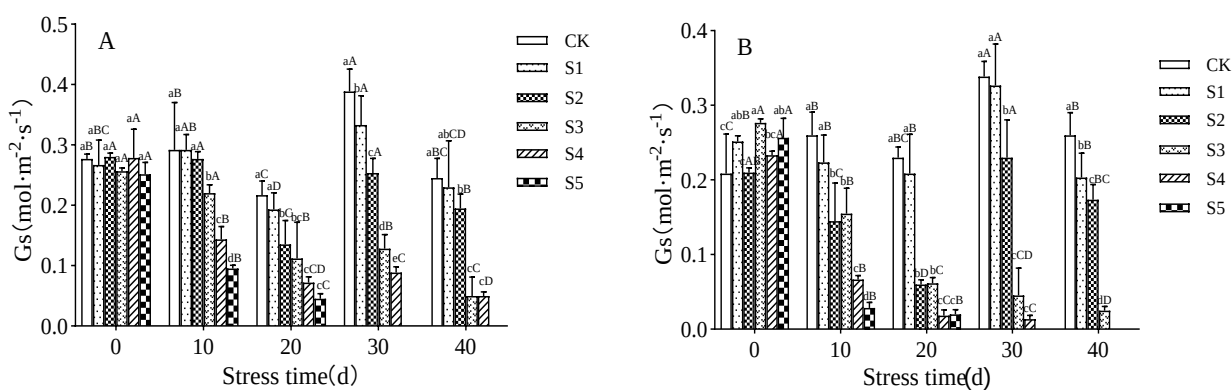
From Fig. 6, with the extension of stress time, the T_r value of *Prunus mume* 'ZaohuaLve' increased first under S1 and S2 treatment, S3 decreased, and S4 decreased first and then decreased again. Over the time, the T_r value of *Prunus mume* 'Meiren' rose to its maximum with S1 and S2 treatment. At this time, it was still significantly lower than CK, but the difference was not significant, and it continued to decrease under S3 and S4 treatment. For *Prunus mume* 'Meiren', all treatments except S1 and S2 was significantly lower than CK.



A. *Prunus mume* 'ZaohuaLve'

B. *Prunus mume* 'Meiren'

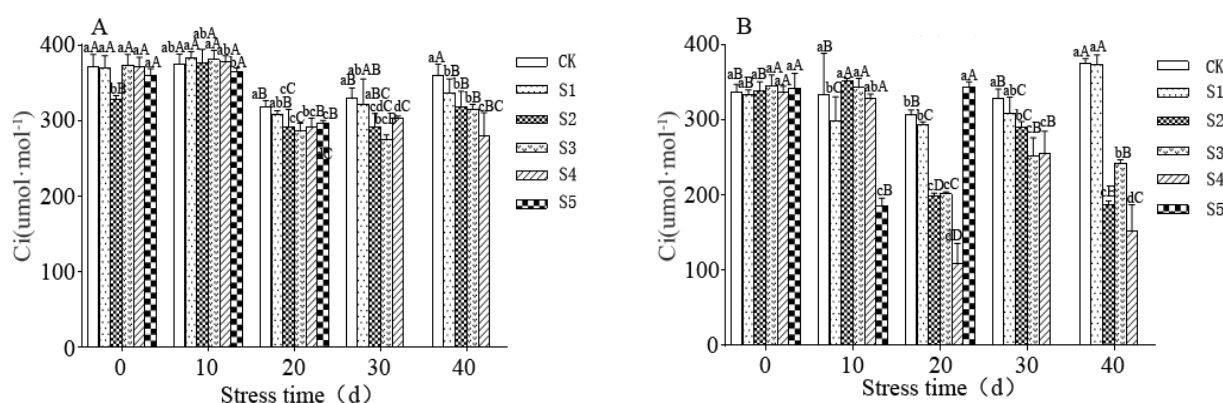
Fig 3. Effects of mixed salt on net photosynthetic rate Pn of the two *Prunus mume*s.



A. *Prunus mume* 'ZaohuaLve'

B. *Prunus mume* 'Meiren'

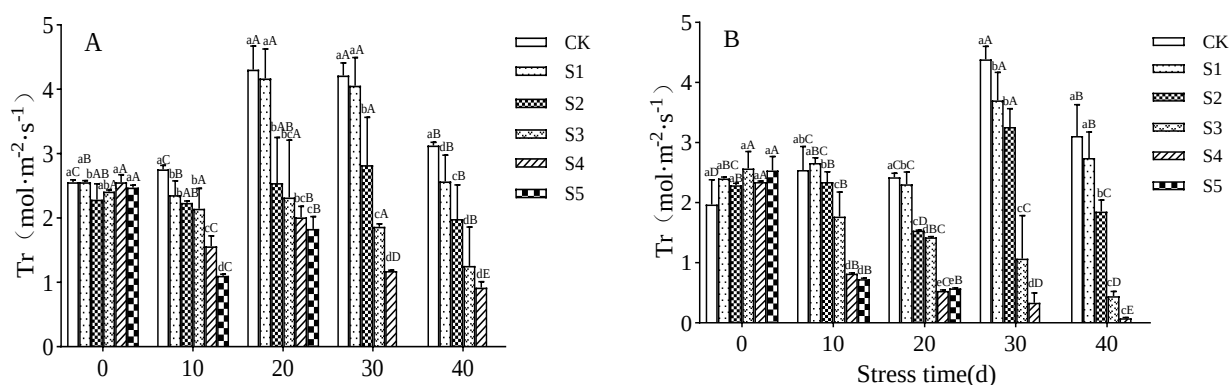
Fig 4. Effects of mixed salt on stomatal conductance Gs of the two *Prunus mume*s.



A. *Prunus mume* 'ZaohuaLve'

B. *Prunus mume* 'Meiren'

Fig 5. Effects of mixed salt on intercellular carbon dioxide concentration Ci of the two *Prunus mume*s.



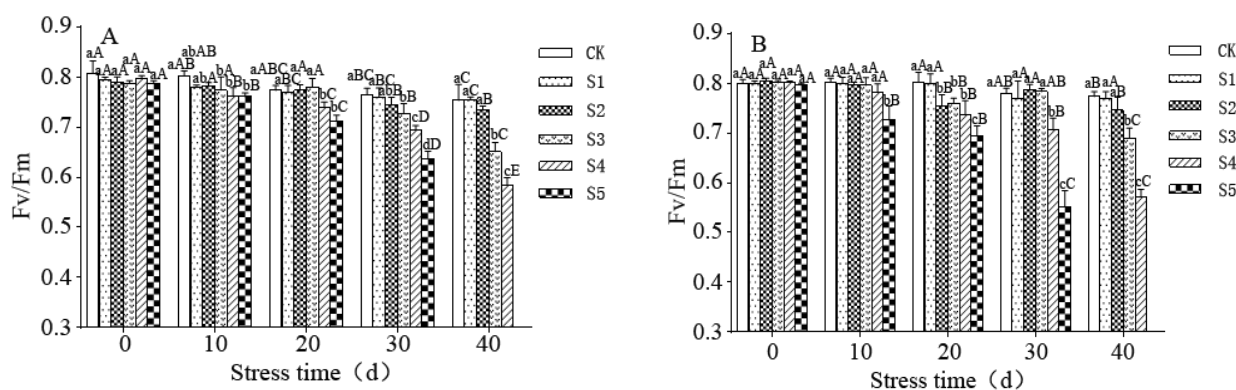
A. *Prunus mume* 'ZaohuaLve'

B. *Prunus mume* 'Meiren'

Fig 6. Effects of mixed salt on transpiration rate Tr of the two *Prunus mume*.

3.2.3. Effect of mixed salt stress on chlorophyll fluorescence kinetic parameters in two *Prunus mume* garden plants.

As shown in Fig.7, the F_v/F_m values of the two *Prunus mume* species decreased with increasing salt concentration and prolonged stress time. At 10d of stress, *Prunus mume* 'Meiren' was significantly reduced under S5 treatment, and *Prunus mume* 'ZaohuaLve' began to decrease significantly when the salt concentration reached S4 treatment. With increasing salt concentration, *Prunus mume* 'Meiren' showed no significant decrease in CK except under S5 high salt treatment. At 40d, the two *Prunus mume* successively showed a significant downward trend under each treatment. The *Prunus mume* 'ZaohuaLve' and *Prunus mume* 'Meiren' were successively significantly decreased by 13.55% and 22.37%, 10.91% and 26.17% under S3 and S4 treatments. Each treatment reached a minimum value at 40d.

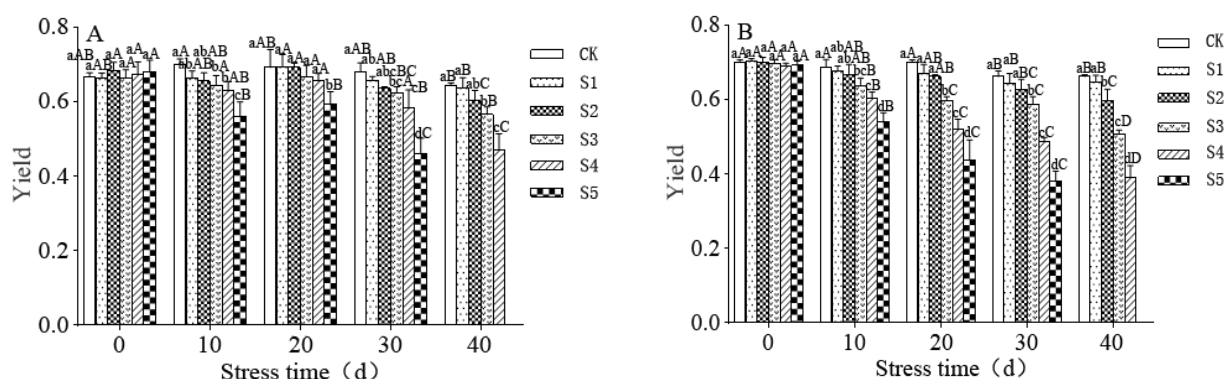


A. *Prunus mume* 'ZaohuaLve'

B. *Prunus mume* 'Meiren'

Fig 7. Effects of mixed salt on maximum photosynthetic efficiency of photosystem II F_v/F_m of the two *Prunus mume*.

As shown in Fig. 8, the yield values of *Prunus mume* were decreased under each treatment along with the prolonged stress time. The yield values of *Prunus mume* 'ZaohuaLve' and *Prunus mume* 'Meiren' under S5 treatment decreased significantly at 10d and reached the minimum at 30d. The yield values of *Prunus mume* 'ZaohuaLve' and *Prunus mume* 'Meiren' under S5 treatment decreased significantly at 10d and reached the minimum at 30d. The yield values in each treatment group were gradually lower than that of the control group. With increasing salt concentration, the yield decreased with lesser decrease in S1, S2, larger and significant difference in S3-S4.

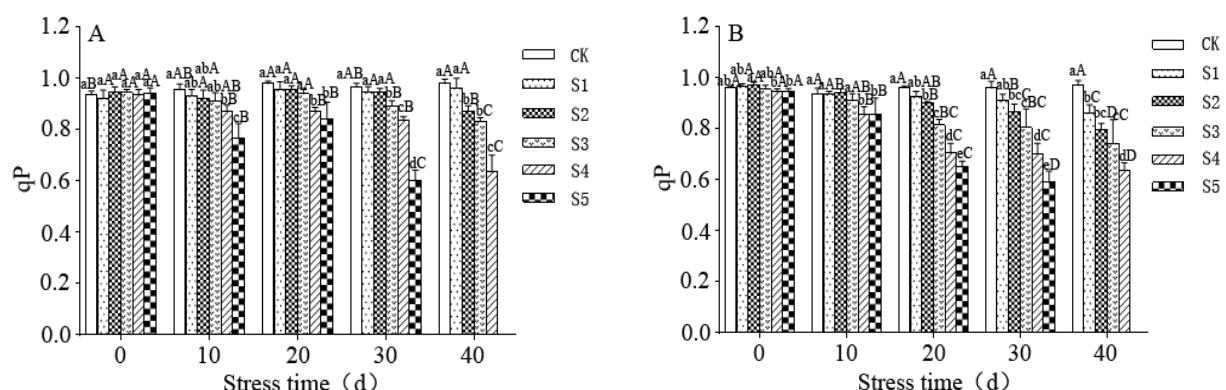


A. *Prunus mume* 'ZaohuaLve'

B. *Prunus mume* 'Meiren'

Fig 8. Effects of mixed salt on actual photosynthetic efficiency of photosystem II Yield of the two *Prunus mumes*.

As shown in Fig. 9, the qP value of *Prunus mume* generally decreased with increasing salt concentration and prolonged stress time. Under the low salt treatment in S1-S2, the qP values of both *Prunus mumes* were not significantly different from CK, and it decreased to the lowest level in S5 treatment. At 40d, *Prunus mume* 'ZaohuaLve' showed no significant difference under S1 treatment from 0d, with a significant reduction of 8.07%, 11.98%, 32.27% and 6.72%, 11.16% and 28.78% under the other treatments. The *Prunus mume* 'Meiren' was significantly reduced by 10.70%, 18.14%, 22.30%, and 32.75% per treatment, respectively.



A. *Prunus mume* 'ZaohuaLve'

B. *Prunus mume* 'Meiren'

Fig 9. Effects of mixed salt on photochemical quenching efficient qP of the two *Prunus mumes*.

4. Discussion and conclusions

Under salt-alkali stress, plant leaves usually show symptoms of water loss, green loss, curling, dry rot, and leaf abscission. In this study, the mixed salt concentrations of *Prunus mume* 'ZaohuaLve' and *Prunus mume* 'Meiren' at the salt hazard index at 50% were 330.189 mmol L⁻¹ and 292.453 mmol L⁻¹, respectively. This shows that the resistance of the two *Prunus mume* plants to mixed salt stress is that *Prunus mume* 'ZaohuaLve' is higher than *Prunus mume* 'Meiren', which is basically consistent with the morphological observations. Leaf length growth and diameter growth decreased in this study, and the decrease gradually increased with increasing salt concentration. This indicates that most growth of plants under salt treatment was inhibited. The growth amount of *Prunus mume* 'ZaohuaLve' leaves increased slightly at S1, which can indicate that for plants with certain salt tolerance, the growth amount of plants can be manifested as low concentration promoting high concentration inhibition. This is similar to the research results from GAO Xiang [9]. For tree species with weak salt tolerance,

there showed a direct reduction trend (the weaker the salt tolerance, the greater the salt concentration), which is consistent with the research results for the neem seedlings from Zhang Yuanlan [10].

As an important photosynthetic pigment, chlorophyll plays an important role in the absorption, transmission and transformation of light energy. The content can reflect the strength of plant photosynthetic ability [11]. In the present study, the chlorophyll content of both *Prunus mume* 'ZaohuaLve' and *Prunus mume* 'Meiren' showed a certain upward trend under S1-S3 treatment, mainly because the medium and low salt concentrations stimulated the protective mechanism in plants [12]. It is also possible that low salt stress promotes cell accumulation of osmoregulatory substances or improves enzymatic activity for the synthesis of chlorophyll in the four plants. As such, the mixed salt disrupts the permeability of the cell membrane, leading to extravasation of numerous chlorophyll molecules [13]. With increasing mixed salt concentration, the chlorophyll content was reduced under S5 treatment, as high salt stress disrupted the stability between the chlorophyll-chloroplast protein complexes, and severely impaired the chloroplast structure and function. At the same time, the chlorophyll enzyme activity increases, promoting the chlorophyll decomposition, resulting in the inhibition of chlorophyll synthesis [14-15]. Salt damage makes it difficult for plants to absorb water and mineral nutrients, causing physiological drought and malnutrition [16], which is consistent with the research results for 'Niudiedu' [16] and alfalfa [17].

Photosynthesis provides material and energy for plants, and it is most prominently affected under mixed salt stress [18], and it will increase gradually with the aggravation of the stress degree [19]. In this study, in two *Prunus mume* plants, Pn, Gs and Tr decreased with increasing mixed salt concentration, while Ci was inconsistent with this trend. As the salt concentration increased, the photosynthetic parameters of *Prunus mume* 'ZaohuaLve' and *Prunus mume* 'Meiren' decreased first and then decreased before the last increase. From this point of view, the limiting factors of photosynthesis in the two *Prunus mume* plants under mixed salt stress are extremely complex. The alkali stress can significantly reduce the net photosynthetic rate Pn, while factors that reduce Pn include stomatal and non-stomatal restriction [20-22]. The decrease of stomatal conductivity Gs reduces the amount of CO₂ through the stomatal chloroplast, and causes the decrease of net photosynthetic rate Pn caused by the decrease of intercellular CO₂ concentration Ci. Non-stomatal factors occurred when decreased photosynthetic activity of mesophyll cells, that is, decreased Gs and increased Ci value. In this study, the trends of Pn, Ci, and Gs values of *Prunus mume* 'Meiren' at 0-20d with S1 and S2 treatment are consistent. This indicates that at this time, *Prunus mume* 'Meiren' is dominated by stomatal restriction, which is the main factor in the decreased Ci value. The Gs decrease leads to reduced CO₂ content into the chloroplast through the stomata and decreased Pn value. At 30-40d, the overall Pn and Gs of *Prunus mume* 'Meiren' decreased under S3 and S4 treatment, with the opposite trend of Ci increasing. This indicates that stomatal regulation ability decreases, CO₂ accumulates between cells, Ci value increases. And decreased photosynthetic activity of mesophyll cells causes decreased Pn value when non-stomatal limitation becomes the main factor. Most studies show that stomatal restriction is predominant in plants under low salt stress, and non-stomatal restriction becomes the dominant factor under high salt stress [23-26]. In this study, *Prunus mume* 'ZaohuaLve' significantly decreased regarding the Pn and Gs values at early 0-10d of salt stress, and the change trend of Ci values was increasing, with non-stomatal restriction as the dominant factor. The changes in Pn, Gs and Ci in the later stage of salt stress are inconsistent, and the two limiting factors may exist simultaneously. The specific causes and mechanism of action remain to be thoroughly studied.

The maximum photosynthetic efficiency Fv/Fm is an important indicator of plant response to stress stress, which can reflect the efficiency of plant light energy utilization. The magnitude of the yield values for the actual photosynthetic efficiency can reflect the openness of the photosystem II reaction center. The photochemical quenching photochemical quenching coefficient indicates that the absorbed light energy acts on the photosynthetic reaction with no other forms of energy dissipation [27]. In this study, the maximum photosynthetic efficiency of *Prunus mume* 'ZaohuaLve' at Fv/Fm under S1 and S2 low salt stress was not significantly different compared with that of CK. This indicates that the photoenergy conversion efficiency of the *Prunus mume* 'ZaohuaLve' PS reaction center is not

diminished under low-salt stress, and that the plants maintain Fv/Fm at high levels through self-regulation. The Fv/Fm of *Prunus mume* 'Meiren' was gradually decreasing, indicating that its PS reaction center was severely damaged with lower salt tolerance than *Prunus mume* 'ZaohuaLve'. The actual photosynthetic efficiency yield and the photochemical quenching coefficient qP of both *Prunus mume* photosystems II were eventually decreased. This is due to some damage caused by mixed salt stress to the PS response center or the primary electron receptor or the PS oxidative transport chain [28]. This is consistent with the research results for ginkgo [24], hackberry and fast-growing white elm [29], and white birch [30].

The overall results showed that both *Prunus mumes* had some salt tolerance at low salt concentration, but with the increase of salt concentration and the prolonged stress time, the leaves completely fell or even died. Overall, *Prunus mume* 'ZaohuaLve' has a better salt tolerance than *Prunus mume* 'Meiren'. This conclusion can provide a theoretical basis for the future application and large-scale planting in urban and rural greening.

Acknowledgement

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