1. Introduction

Currently, about 22% of the agricultural land in the world is negatively impacted by saline alkali conditions (Bhatnagar-Mathur et al. 2008; Munns and Tester 2008). The total saline soil in China is about $3.6 \times 10^7$ hm$^2$, and $9.2 \times 10^7$ hm$^2$ of the cultivated land area is facing salinization, mainly in the coastal area, arid, and semi-arid areas (Zhang et al. 2005). In addition, because of population growth, industrial pollution, irrational irrigation and excessive fertilization, the area impacted by secondary salinization is still expanding. This is directly attributable to the sharp decline in usable cultivated land area, and seriously threatens both food security and the stability of natural ecosystems in China (Wang et al. 2009; Landi et al. 2017). Salt is common in the soil and is a necessary component of the soil. It is also an essential nutrient for normal plant growth (Browell and Crossland 1972; Wang et al. 2001). Normal salt content plays an important role in maintaining normal physiological functions of plants (Fang et al. 2008). However, excessive salt in the soil can cause osmotic stress (Munns and James 2006), ion toxicity (Zheng et al. 2003; Parida and Das 2005; Ali et al. 2017), interfere with nutrient ion balance (Akita and Cabusla 2000; Yan et al. 2006), and affect plant growth and physiological functions (Greenway and Munns 1980). The saline alkaline stress on plants is mainly from the neutral salts NaCl and Na$_2$SO$_4$, and the alkaline salts Na$_2$CO$_3$ and NaHCO$_3$ (Yang et al. 2008; Zhao et al. 2016). Many studies have found that the stress from alkaline salts is far more harmful to plant growth and development than the salt stress from neutral salts (Yang et al. 2007; Zhang et al. 2009). Under alkaline stress, plants have to bear the same osmotic stress and ion toxicity as salt stress, but they also have to resist the high pH stress. The impacts from alkaline salt stress are significantly greater than the effects of neutral salts on plants’ nutrient absorption (Sarkar and Wynjones 1982; Xu et al. 2011), photosynthesis (Bai et al. 2008), ion balance (Shi and Zhao 1997; Qu and Zhao 2004), reactive oxygen species production (Moradi and Ismail 2007; Zhang et al. 2009) and other aspects of crucial physiology.

Photosynthesis ensures normal plant growth under stress conditions, and salt stress inhibits growth through its impact on plant photosynthetic capacity (Ma et al. 1997). Salt stress could inhibit the activity of the PSI reaction center in plant leaves, by reducing the activity of the oxygen-evolving complex (OEC) at the donor side of PSI and degrading D$_1$ protein on the acceptor side of the PSI. A decrease in electron transfer rate would result in the accumulation of excess electrons from the electron transfer chain and lead to electron leakage. The leaked electrons would attack the free oxygen molecules in the cell, lead to an outbreak of reactive oxygen species (ROS) and exacerbate the damage in the PSI reaction center (Chen et al. 2010; Bialasek et al. 2017), and even result in the...
peroxidation or dissociation of the thylakoid membranes (Mitsuya et al. 2000) In addition to PSII, PSI is also sensitive to salt stress. Damage to PSI would lead to further inhibition of electron transfer and aggravate the extent of damage on PSII (Sonoike 2011; Zhang, Li, et al. 2012).

While mainly a food crop, sorghum [Sorghum bicolor (L.) Moench] can also be used as a forage crop. Sorghum is a C4 plant, characterized by its high photosynthetic capacity and high yield, and its strong resistance to drought, salt and other stressors. It is one of the major economic crops in arid and semi-arid regions in China (Gao et al. 2012). Although there is a great deal of research focused on sorghum’s salt tolerance (He et al. 2012; Sun et al. 2012), relatively few studies are focused on the effects of different types of salt stress on sorghum’s growth and photosynthesis, especially on the mechanism of the effects of alkaline versus neutral salt stress on the functions of PSII and PSI of sorghum leaves. Therefore, in this study, the effects of different types of sodium salt (two neutral salts, NaCl and Na₂SO₄; and two alkaline salts, NaHCO₃ and Na₂CO₃) at the same Na⁺ concentration (100 mmol·L⁻¹) were characterized on sorghum leaf growth parameters. In depth characterization of PSII and PSI function was studied in order to provide basic data for increasing the efficiency of sorghum agriculture in saline alkaline soils.

2. Materials and methods

2.1. Experimental materials and treatments

The experiment was conducted from March to May of 2017 at the Soil Science Laboratory at Northeast Agricultural University. The seeds of the red sorghum variety Longza 17 were provided by the Breeding Institute of the Heilongjiang Academy of Agricultural Sciences. The seeds were sown in seedling trays that were 50 cm long, 25 cm wide and 8 cm high. Fifty seedling holes were evenly distributed in peat soil substrate in each seedling tray. The cultivation conditions were as follows: temperature 25/23°C (light/dark), light intensity 200μmol·m⁻²·s⁻¹, light cycle: 12/12h (light/dark). Two seeds were planted in each seedling hole, and thinning was done after sprouting, leaving one relatively robust seedling in each hole. When the seedlings grew to around 10 cm tall, they were carefully pulled out of the seedling tray and the culture substrate attached to the root surface was washed off. The seedlings were then fixed in the planting basket with sponge and the planting basket was fixed onto a foam board. The foam board was then floated in a black square incubator 20 cm long, 15 cm wide and 20 cm high. Five L of ½ Hoagland complete nutrient solution was placed in each incubator. The size of the foam board and the inner diameter of the incubator were the same so that the culture medium was completely light tight. Six seedlings were planted in each incubator. A ventilation device was connected to each incubator and operated continuously for 24h. The nutrient solution was replaced every five days. Salt stress treatment began after 15 days cultivation of the seedlings with white new root system growing. Four different types of sodium salt, two neutral salts, NaCl and Na₂SO₄, and two alkaline salts, NaHCO₃ and Na₂CO₃, were selected to be tested in the experiment. The Na⁺ concentration used in each sodium salt treatment group was fixed at 100 mmol·L⁻¹. Normal nutrient solution was used as a control and was designated as CK. The culture condition after salt treatment was the same as the condition during seedling cultivation. Fifteen days after the salt stress treatment, plant growth parameters and chlorophyll fluorescence parameters of different plants were determined.

2.2. Items and methods of determination

To determine the relevant growth parameters, after harvesting the plants from different treatments, the roots were washed with distilled water to remove the salt on the surface of the roots and dried using absorbent paper. The fresh weights of the above-ground and underground tissues were measured separately, then each was put into a separate envelope and incubated at 105°C for 30 min to fix, and then 80°C to dry to obtain the dry weights of each portion of the plant.

M-PEA continuous excitation fluorescence instrument (Handy, UK) was used to determine the fast chlorophyll fluorescence induction kinetics (OJIP fluorescence induction curves) and the 820 nm light reflection curves of the last fully expanded leaf of the plants from different treatment groups. The leaf was adapted to darkness for 30 min before testing. The four characteristic points: O, J, I and P on the OJIP curve corresponded to time points of 0, 2, 30 and 1000 ms, and the corresponding relative fluorescence intensities were expressed as F₀, F₁, F₃ and F₅. The corresponding time points of 0.15 and 0.3 ms on the OJIP curve were defined as L and K respectively, and the corresponding relative fluorescence intensities were expressed as F₁ and F₃ respectively. Standardizations of O–P, O–J and O–K on the OJIP curves of different treatments were carried out respectively by defining the relative fluorescence intensity of O as 0, and the relative fluorescence intensities of P, J and K as 1. The formulas for the standardization were: \( V_{O,P} = \frac{F_{O,F_{O}}}{(F_{O,F_{O}}+F_{V_{O,J}})} \), \( V_{O,J} = \frac{F_{O,F_{O}}}{(F_{O,F_{O}}+F_{V_{O,J}})} \), \( V_{O,K} = \frac{F_{O,F_{O}}}{(F_{O,F_{O}}+F_{V_{O,K}})} \). In the formulas, \( F_{O} \) is the relative fluorescence intensity at different time points. The relative variable fluorescence at the three characteristic points L, K and J on the standardized curve were expressed as \( V_{L,J} = \frac{F_{L,F_{L}}}{(F_{L,F_{L}}+F_{V_{L,J}})} \), \( V_{K,J} = \frac{F_{K,F_{K}}}{(F_{K,F_{K}}+F_{V_{K,J}})} \), \( V_{J,J} = \frac{F_{J,F_{J}}}{(F_{J,F_{J}}+F_{V_{J,J}})} \). The differences between CK and \( V_{O,P} \), \( V_{O,J} \) and \( V_{O,K} \) curves of the plant leaves under different salt treatments were determined and were expressed as \( \Delta V_{O,P} \), \( \Delta V_{O,J} \) and \( \Delta V_{O,K} \) respectively (Zhang et al. 2011). The PSII maximum photochemical efficiency (\( F_{V_{O,P}} \)), the total performance index (\( P_{IABS} \)), the photosynthesis indices based on the absorption of light energy (\( P_{ABS} \)), and the number of the active response centers per unit area (\( RC/CS_{m} \)) were obtained through JIP-test analysis of OJIP curves by the method of Strasser et al. (1995). The activity of the PS I reaction center was reflected by the initial slope of the 820 nm light reflected curve \( \Delta I/L_{I} \), which, \( I_{I} \) and \( \Delta I \) represent the maximum value of the 820 nm light reflection curve and the difference between the maximum and the minimum values, respectively.

2.3. Data analysis

Excel (2003) and SPSS (22.0) software were used for statistical analysis. One-way ANOVA and least significant difference (LSD) were used for the comparison of the differences between different data sets.
3. Results and analysis

3.1. The growth characteristics of sorghum plants under the four types of sodium salt stress

Figure 1 shows that the effects of different types of salt stress on sorghum growth above-ground and underground were significantly different. The two neutral salts, NaCl and Na$_2$SO$_4$ had little effects on the fresh and dry weights of the underground portion of sorghum plants, and the differences compared to CK were not significant. However, under the stresses of the two alkaline salts, NaHCO$_3$ and Na$_2$CO$_3$, the fresh weights and dry weights of sorghum above-ground and underground were significantly reduced. Dry weight in particular was very significantly reduced, and the magnitude of the reduction under Na$_2$SO$_4$ stress was even bigger. In contrary to the underground portion of sorghum plants, the stresses from all four salts resulted in significant reductions on both the fresh and dry weights of the above-ground portion of the plants, and the magnitudes of reduction were all significantly greater than that of the underground portion. The differences in the fresh weights of the above-ground portion of sorghum under the four sodium salt stresses were all significant when compared to CK, but the differences within the two neutral salts and the two alkaline salts were not significant. The extent of reduction in the dry weights of the above-ground portion of sorghum under the stresses of the two alkaline salts was also significantly greater than that under the stresses of the two neutral salts.

3.2. OJIP curves of sorghum leaves under the four types of sodium salt stress

Figure 2 shows that the shapes of the OJIP curves of the sorghum leaves were significantly different under all four types of sodium salt stress, and the ranges of the variations of the relative fluorescence intensity at each characteristic point on the OJIP curve also differed. Compared with CK, there were no significant changes in the initial fluorescence, $F_o$, under neutral salt stress, while there were 10.61% and 15.41% reductions of the maximum fluorescence, $F_m$, under Na$_2$SO$_4$ and NaCl treatments, respectively, with a greater magnitude reduction induced by Na$_2$SO$_4$ stress. Under the stress of the two alkaline salts, the $F_o$ of sorghum leaves increased slightly, but $F_m$ decreased significantly. The extent of the reduction in $F_m$ under NaHCO$_3$ stress showed no significant difference compared to the two neutral salts, but was significantly reduced by 28.98% when compared with CK.

3.3. The standardized O–P, O–J and O–K curves under the four types of sodium salt stress and the differences compared with CK

The curve was standardized in Figure 3 by defining the relative fluorescence intensity of $F_o$ on the original OJIP curves as zero and the relative fluorescence intensities of points P, J and K as 1. Under different types of sodium salt stress, the relative fluorescence intensity of point J at 2 ms on the standardized O–P curve $V_J$ and the relative fluorescence intensity of point 1 at 30 ms $V_I$ showed increasing trends compared with CK, and the extent of the increase in $V_J$ was significantly larger than $V_I$ (Figure 3(A,B)). The relative fluorescence intensity of point K at 0.3 ms $V_K$ on the standardized O–J and O–K curves (Figure 3(C,D)) and the relative fluorescence intensity of point L at 0.15 ms $V_L$ (Figure 3(E,F)) also showed increasing trends. Comparing the four different sodium salt treatments, in addition to observing relatively small differences between $V_K$ and $V_I$, significantly higher differences of $V_J$ and $V_L$ under the stress of the two alkaline salts were seen when compared to the two neutral salts. The difference between NaCl and Na$_2$SO$_4$ treatments was relatively small, while $V_J$ and $V_L$ under Na$_2$CO$_3$ stress were both significantly higher than those under NaHCO$_3$ stress.
3.4. Relative variable fluorescence of sorghum leaves at each characteristic point under the four types of sodium salt stress

Quantitative analysis of the changes of the relative variable fluorescence at each characteristic point showed that under different types of sodium salt stress at 100 mmol·L⁻¹ Na⁺, the values of $V_J$, $V_I$, $V_K$ and $V_L$ showed increasing trends, but the magnitude of the increase of the parameters was significantly different (Figure 4). The values of $V_J$, $V_I$, $V_K$ and $V_L$ under the stress of the two neutral salts did not show a significant increase when compared with CK, while under the stress of the two alkaline salts, $V_J$ increased 23.79% ($P < 0.01$) and 29.09% ($P < 0.01$), respectively, when compared with CK, and $V_I$ increased 15.49% ($P < 0.05$) and 20.23% ($P < 0.01$), respectively, when compared with CK. The magnitude of increases of $V_I$ and $V_K$ were relatively smaller.

3.5. PS II reaction center activity in sorghum leaves under the four types of sodium salt stress

Figure 5 shows that under different salt stresses, $F_v/F_m$, $P_{I_{abs}}$ and $P_{total}$, the parameters associated with PS II reaction center activity in plant leaves, all values were significantly decreased. There were no significant differences of $F_v/F_m$ and $P_{I_{abs}}$ under stress from the neutral salts NaCl and Na₂SO₄ compared with CK, while $P_{total}$ decreased 39.95% ($P < 0.05$) and 45.45% ($P < 0.05$), respectively. Under the stresses of the two alkaline salts, especially under Na₂CO₃ stress, the decrease in magnitude of $F_v/F_m$, $P_{I_{abs}}$ and $P_{total}$ were all significantly larger than those under the stress of the two neutral salts. Under different types of salt stress, the number of reactive reaction centers per unit area ($RC/CS_m$) of the sorghum leaves were significantly decreased, with a consistent order of
decreasing magnitude, \( \text{Na}_{2}\text{CO}_3 > \text{NaHCO}_3 > \text{Na}_2\text{SO}_4 > \text{NaCl} \). There were no significant differences between CK and treatments with \( \text{Na}_2\text{SO}_4 \) and \( \text{NaCl} \), while \( \text{RC/CS}_m \) values under treatments with \( \text{NaHCO}_3 \) and \( \text{Na}_2\text{CO}_3 \) were decreased by 78.47% \((P < 0.01)\) and 93.55% \((P < 0.01)\), respectively.

![Figure 4](image1.png)

**Figure 4.** Effects of different types of sodium salt stress on \( V_I \) (A), \( V_J \) (B), \( V_K \) (C) and \( V_L \) (D) of the leaves of sorghum.

Note: Different lowercase letters in the figure indicate significant difference \((p < 0.05)\); different capital letters indicate very significant difference \((p < 0.01)\).

![Figure 5](image2.png)

**Figure 5.** Effects of different types of sodium salt stress on \( \text{F}_v/\text{F}_m \) (A), \( \text{PI}_{\text{abs}} \) (B), \( \text{PI}_{\text{total}} \) (C) and \( \text{RC/CS}_m \) (D) of the leaves of sorghum.

Note: Different lowercase letters in the figure indicate significant difference \((p < 0.05)\); different capital letters indicate very significant difference \((p < 0.01)\).
3.6. Relative changes of the modulated reflected signal 820 nm (MR820 nm) in sorghum leaves under the four types of sodium salt stress and the activity of PSI

Figure 6 shows that there were significant changes in the shapes of the red-light-induced 820 nm reflection signals in this experiment. Under different types of salt stress, the amplitudes of the 820 nm light reflection signal were reduced. However, no significant difference in amplitude was observed between NaCl induced stress and CK, while the amplitude changes under the stresses of Na₂SO₄, NaHCO₃, and Na₂CO₃ were relatively large, especially under Na₂CO₃ stress. The relative signal drop at 820 nm during red light irradiation, \((\Delta/\Delta)\), reflects PSI activity. Quantitative analysis of the changes of \((\Delta/\Delta)\) revealed that the values showed no significant difference between NaCl induced stress and CK, while under the stresses of Na₂SO₄, NaHCO₃, and Na₂CO₃, the values decreased by 23.22% \((P < 0.05)\), 37.95% \((P < 0.01)\) and 50.92% \((P < 0.01)\), respectively.

4. Discussion

The inhibition of plant growth and physiological function by sodium salt stress is mainly related to Na⁺ poisoning (Parida and Das 2005). Different types of sodium salt at a 100 mmol·L⁻¹ Na⁺ concentration significantly inhibited sorghum growth. However, the effects of different types of sodium salt on the above-ground and underground portions of the plants were different. The effects of the neutral salts on the underground portion of plant growth were small, but the alkaline salts, especially Na₂CO₃, significantly lowered both the fresh and dry weights of the underground portion of sorghum. This effect could be related to the high pH damage from the alkaline salts on the sorghum root system, which is consistent with our previous results on the study of mulberry (Zhang, Zhang, et al. 2012; Zhang et al. 2013). The inhibition of the root system growth would lead to difficulties in absorbing nutrients and water, affecting the above-ground growth of plants. Although the fresh and dry weights of the underground portion of sorghum plants were similar under the stresses of the alkaline salts, and were significantly lower than under the treatment by the neutral salts, the differences between the fresh and dry weights of the above-ground portions of the plants of the two neutral salt treatments and the two alkaline salt treatments were not significant, indicating that relatively high alkalinity is an important limit in sorghum growth.

The effect of different types of salt stress on the PSII reaction center activity and electron transfer ability in sorghum leaves was studied by using fast chlorophyll fluorescence dynamics analysis. The results showed that different types of salt stress significantly changed the shape of OJIP curves of sorghum leaves, and led to different degrees of reduction in \(F_{v}/F_{m}\), \(PI_{abs}\), and \(PI_{total}\). These parameters indicate the activity of the PSII reaction center in the plant leaves (Zhang et al. 2016), indicating that different types of salt stress significantly decreased the activity of the PSII reaction center in sorghum leaves. In addition, under different types of salt stress, the numbers of reaction centers per unit area \((RC/CS_{m})\) were significantly reduced, indicating that salt stress also leads to the inactivation of some of the reaction centers in sorghum leaves. By comparing the differences between different types of salt stress, it was observed that the magnitude of decrease in \(F_{v}/F_{m}\), \(PI_{abs}\), \(PI_{total}\), and \(RC/CS_{m}\) from the stresses induced by the two neutral salts were significantly smaller than the stresses induced by the two alkaline salts. Especially under stress by the higher alkalinity salt, Na₂CO₃, the damage to the activity of the PSII reaction center was more severe, indicating that the main reason for the decreased PSII reaction center activity in sorghum leaves is not only due to the toxic effect of Na⁺, but is also related to the relatively high pH value of the alkaline salt. Moreover, the ratio of inactivated PSII reaction centers in sorghum leaves was increased under high pH value.

In order to further analyze the damaged sites of the photosynthetic apparatus in sorghum leaves by different types of salt stress, the original OJIP curve from each treatment was standardized, respectively. Compared to CK, different types of sodium salt stress resulted in different degrees of increases in \(V_{1}\) and \(V_{t}\). The magnitude of increase in \(V_{1}\) under the alkaline salt stress was greater than that under the stress of the neutral salts, while the difference in the values of \(V_{1}\) under the stresses of different types of sodium salts was not significant. \(V_{1}\) represents the degree of closure of the reaction center. The increase in the value of \(V_{1}\) is the result of the blockage of electron transfer from \(Q_{A}\) to \(Q_{B}\) in the photosynthesis electron transfer chain, leading to the accumulation of \(Q_{A}\) (Strasser et al. 1995; Haldimann and Strasser 1999), while the increase in \(V_{t}\) is the result of inhibition of the process of electron transfer from \(Q_{A}\) to \(Q_{B}\), which reflects the heterogeneity of the PQ pool (Govindjee 1995; Li et al. 2005). These results indicate that the blockage of electron transfer in sorghum mainly occurred from \(Q_{A}\) to \(Q_{B}\) at the acceptor side of PS II under salt stress, and the inhibitory effect of the alkaline salts was significantly greater than that of the neutral salts.

The effects of different types of sodium salt stress on the PQ pool of the sorghum leaves were not significant, and the differences among different types of sodium salt treatments were small. The differences among different types of sodium salt stress were not significant for \(V_{1}\). There were some increases in the relative variable fluorescence \(F_{v}/F_{m}\) at 0.3 ms point K. The increase in \(V_{t}\) is considered to be a specific sign of damage to the oxygen-evolving complex (OEC) on the electron donor side of PSII (Zhang et al. 2017). These results indicated that the OEC was affected by different types of sodium salt stress, but the sensitivities showed no significant differences under the stresses of alkaline salts from that of neutral salts. The decrease in the activity of the OEC at the electron donor side of PSII would lead to incomplete cleavage of water, producing \(H_{2}O_{2}\), while the blockage of the electron transfer at the acceptor side of PSII would lead to leakage of the excess electrons, which can attack the free \(O_{2}\) in the cells and generate superoxide anions. Reactive oxygen species such as \(H_{2}O_{2}\) and superoxide anions can increase the degree of cell membrane peroxidation, leading to electrolyte extravasation, which can affect the normal functioning of cell membranes (Chen et al. 2005; Venkatesh et al. 2012).

The thylakoid membrane in the chloroplast is also one of the major sites attacked by the reactive oxygen species. The stability of the thylakoid membrane plays an important role in maintaining normal physiological function of plants. An increase in \(V_{1}\) is considered to be an important sign of changes in thylakoid membrane fluidity, indicating decreased function and structural integrity (Tóth et al. 2005; Essemine et al. 2012). In this study, the differences in \(V_{1}\) under neutral
salt stress were not significant when compared with CK, but under alkaline salt stress, V1 values were significantly increased when compared to CK, especially under Na2CO3 stress, indicating that the impact of alkaline salt on the thylakoid membranes of sorghum leaves was significantly greater than the impact of the neutral salts. In addition, the changes of V1 under different treatments were consistent with the changes of V2, indicating that the main reason for the degradation of the thylakoid membrane in sorghum leaves is the blockage of the electron transfer from QA to QB on the electron acceptor side.

Under stress conditions, both the PSI and PSII reaction centers are often attacked. Some studies have found that PSI is more vulnerable to injury by stress than PSII (Sonoike and Terashima 1994; Zhang, Yang, et al. 2012). When the activity of PSI is decreased, the electron transport from PSII to PSI is often inhibited, which increases damage to PSII (Bu et al. 2009; Zhang et al. 2009). The relative drop in the light signal at 820 nm during the red light irradiation process (ΔI/I0) is an important indicator reflecting the activity of PSI (Li et al. 2009). In this study, ΔI/I0 showed no significant difference compared with CK under NaCl stress, while ΔI/I0 under other types of sodium salt stress were all significantly decreased, especially under alkaline salt stress, indicating that different types of sodium salt stress can all inhibit the activity of PSI in sorghum leaves. In addition, the trends of changes in ΔI/I0, Fv/Fm, PIabs and PItotal were similar, indicating that the sensitivities of the two light reaction centers, PSII and PSI, to salinity stress were similar, and that in addition to the influence of excessive Na+, they were also affected by alkalinity, in which a higher pH value aggravated the effects of salt damage on PSI and PSII in sorghum leaves.

5. Conclusion
Different types of sodium salt stress at a consistent concentration of 100 mmol·L−1 Na+ significantly inhibited the growth of sorghum plants. Alkaline salts had an especially significant negative impact on sorghum root systems, which resulted in further inhibition of the growth of the above-ground portion. Different types of sodium salt significantly inhibited the activities of PSII and PSI in sorghum leaves and the damage to the two photosynthetic systems were basically consistent. The reason for the decrease in PSII activity in sorghum leaves was related to the damages to both the donor side and the acceptor side of the PSII. There were no significant differences in the extent of damages on the donor side of the PSII by neutral or alkaline salt stresses, but on the acceptor side of PSII, the sensitivity to the two alkaline salts was significantly greater than that of the two neutral salts. This was one of the reasons for the relatively more severe damages on PSII activity and thylakoid membranes under the stress of alkaline salts. There was a consistent impact order of different types of sodium salt on the growth and photosynthetic function of sorghum leaves, of Na2CO3 > NaHCO3 > Na2SO4 > NaCl. Therefore, when planting and popularizing sorghum cultivation in saline and alkaline land, the impact of soil alkalinity should be considered in addition to the impact of salt damage.

Acknowledgments
This work was supported and funded by The National Natural Science Fund (31500323, 41701289).

Disclosure statement
No potential conflict of interest was reported by the authors.

Funding
This work was supported by The National Natural Science Foundation of China: [grant number 31500323, 41701289].

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