Effects of Salt Stress on Growth and Inorganic Ion Distribution in *Narcissus tazetta* L. var. *chinensis* Roem. Seedlings

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Additional index words. *Narcissus tazetta* var. *chinensis* Roem., substrate salinity, salt spray, ash content, ion distribution

Abstract. *Narcissus tazetta* L. var. *chinensis* Roem. seedlings were subjected to substrate salinity and salt spray during greenhouse cultivation. The results demonstrated that *N. tazetta* L. seedlings treated with substrate salinity and salt spray exhibited slower growth rates than the control group. The sedimentation of Na⁺ and Cl⁻ was primarily observed in the leaf apex, which was consistent with the location of lesions induced by salt stress. Under the two methods of salt stress, the mass fraction of ash in the leaf was significantly higher than that in the control group ($P < 0.05$). The sedimentation of Na⁺ and Cl⁻ was mostly distributed in young leaves in the salt spray treatment, whereas the sedimentation was mostly distributed in old leaves under substrate salinity. There was a significant positive correlation between contents of Na⁺ and Cl⁻ under the two methods of salt stress ($P < 0.01$). Not only the mass concentrations of Ca²⁺, Mg²⁺, Na⁺, K⁺, and Cl⁻ in the seedlings exhibited variation, but also the distribution of mineral elements in the seedlings changed after both salt stress treatments. Moreover, the ratio of K⁺/Na⁺ under salt spray was greater than that under substrate salinity at the 300 mM NaCl treatment level. These results show that ion toxicity in *N. tazetta* L. seedlings was more serious under substrate salinity than under salt spray.

The ornamental and economic value of *N. tazetta* L. var. *chinensis* Roem. is high. This variety is widely cultivated in the coastal area of Zhangzhou City, Fujian Province. In this area, there is a large amount of precipitation and uneven distribution that varies greatly with seasonal change. This pattern of precipitation aggravates soil salinization. Strong wind and waves in coastal areas lead to the deposition of numerous water droplets with dissolved sodium chloride content. These droplets settle on plant leaves and permeate the soil. These minerals can be spread to areas that are relatively far from the coast via the forces of wind and gravity. This salinization could pose a severe threat to the plants, as it can lead to withering and even death (Ogura and Yura, 2008). Soil salinization and salt fog have adverse effects on the growth and ornamental value of *N. tazetta* L. Salt is

therefore an important nonbiological limiting factor for the promotion of growth (Tester, 2003). Thus, it is important to understand the salt injury mechanism of salt stress in *N. tazetta* L.

Most plants are sensitive to salt stress, and their growth is inhibited in saline environments (Deinlein et al., 2014; Maser et al., 2002). Generally, plants are most sensitive to salt stress during the period of seed germination and seedling growth (Kohli et al., 2013). The pathogenic effects of salt on plants are mainly manifested via ion toxicity, osmotic stress, and nutritional imbalance (Flowers and Colmer, 2008; Ghader, 2017; Hand et al., 2011; Julkowska and Testerink, 2015; Munns, 2005). There is some controversy as to whether salt injury is mainly an Na⁺ effect or a Cl⁻ effect. Increases in Na⁺ will antagonize the absorption of other ions (e.g., K⁺, Mg²⁺, and Ca²⁺), causing nutritional deficiency and destroying the osmotic balance in the plant (Maathuis and Amtmann, 1999). The reduction of K⁺/Na⁺ ratio is a typical indicator of ion imbalance in plant cells under salt stress (Wei et al., 2015). To date, most studies have focused on plant responses to substrate salinity (Aghaleh et al., 2011; Ashraf and Akram, 2009; Julkowska and

Testerink, 2015; Munns and Tester, 2008; Tavakkoli et al., 2011; Wang et al., 2017). Studies have rarely investigated the influence of salt spray (Megan, 2006; Ogura and Yura, 2008; Spano and Bottega, 2016), especially salt injury on the different ages and the different parts of plant leaves (Wang and Lin, 1999). There have been many studies on intracellular ion separation, but there have been few studies on the type of extracellular ion separation that occurs in leaves. Therefore, it is difficult to explain the mechanism of leaf apex damage that is primarily caused by salt stress (Tester, 2003), and it is worth studying these effects under salt spray and substrate salinity treatments. The results will be useful for the cultivation and management of *N. tazetta* L. and other ornamental plants in coastal areas.

In our experiments, *N. tazetta* L. seedlings were subjected to substrate salinity and salt spray treatments in a greenhouse environment. The growth rate, the allocation of five mineral elements (Ca²⁺, Mg²⁺, Na⁺, K⁺, and Cl⁻), and the mass fraction of ash at different ages and in various parts of the leaf were measured and compared. The results may guide salt injury diagnosis and prevention measures and provide a basis for screening salt tolerant species.

Materials and Methods

Plant materials and culture

Narcissus tazetta L. var. *chinensis* Roem. seedlings were selected as the research material. They were planted in plastic pots (25 × 18 cm) and maintained in the greenhouse of Minnan Normal University. The temperature of the greenhouse was maintained at 20 ± 2 °C/15 ± 2 °C, and the photoperiod was ≈14 h/10 h (day/night). When the leaves of *N. tazetta* L. seedlings grew to ≈10 cm length, 100 seedlings with consistent growth were transferred to plastic pots filled with 1/2 Hoagland hydroponic solution.

Narcissus tazetta L. seedlings were subjected to substrate salinity and salt spray treatments. There were six treatment groups. The control group was continually cultured in 1/2 strength Hoagland hydroponic solution. One group was cultured in 1/2 Hoagland and was sprayed each day with 10 mL of 300 mM NaCl at 5:00 PM. Four groups were treated with 1/2 Hoagland plus NaCl (i.e., 100, 200, 300, and 400 mM NaCl). The culture solution in plastic pots was renewed every 7 d. The treatments were repeated three times, and each treatment had 10 random seedlings. After 28 d of treatment, seedlings were sampled to measure plant height, leaf number, the growth, injury, the mass fraction of ash, and the mass concentrations of Ca²⁺, Mg²⁺, Na⁺, K⁺, and Cl⁻. These measurements help illuminate the mechanism of salt injury in the study variety.

Methods

The leaves were classified as young leaves, mature leaves, and old leaves according to their age. Young leaves are tender and

Received for publication 16 Apr. 2018. Accepted for publication 16 May 2018.

This research is supported by National Natural Science Foundation of China (NSFC) (cxt2013); science and technology major project of Fujian (2017N01010156).

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those that appear within seven growth days, old leaves are defined as those that have existed for at least 28 d, and mature leaves are those that have existed in the range of 14–21 d. After collecting young leaves, mature leaves, and old leaves, the salt remaining on the leaves was washed with distilled water. The leaves can be divided into three parts: leaf apex (1/3 crosscut near the leaf tip), leaf margin (1/4 longitudinal part on both ends of the leaf after removing the leaf tip), and leaf middle (leaf remainder after removing the leaf tip and leaf margin) (Wang and Lin, 1999).

Morphological. *Narcissus tazetta* L. seedlings were selected randomly and measured to determine plant height between root base and stem top, leaf number, and the growth situation, and symptoms of plant stress.

The mass fraction of ash. All plants were randomized to treatment groups, and 10 plants were measured for each treatment (Yasui et al., 1986). *Narcissus tazetta* L. seedlings were then rinsed in distilled water, subjected to heat at 100 °C for 10 min and dried to a constant weight at 80 °C for measurement of plant dry matter weight. The mass fraction of ash was then examined via the dry ashing method (525 °C ± 25 °C, for 4 h).

The mass concentrations of Ca^{2+} , Mg^{2+} , Na^+ , K^+ , and Cl^- . Extraction and measurement of Ca^{2+} , Mg^{2+} , Na^+ , K^+ , and Cl^- in *N. tazetta* L. seedlings were performed according to Yue et al (2012) with minor modifications. *Narcissus tazetta* L. plants were fully rinsed in distilled water, subjected to heat at 100 °C for 10 min, and dried to a constant weight at 80 °C. Dry matter was ground and screened with a 60-mesh sieve. Next, 100 mg of each sample was placed into a test tube (25 mL) and 20 mL of deionized H_2O was added. This mixture was boiled for 2 h, and then filtered and deionized H_2O was added to create a final volume of 50 mL. Concentrations and absolute contents of mineral elements including potassium, sodium, calcium, and magnesium were determined via atomic absorption spectrophotometry (AA800 type atomic absorption spectrometer). The content of chloride was determined via a AgNO_3 titration method (Adachi and Kobayashi, 2008). Measurement of K^+/Na^+ in *N. tazetta* L. seedlings was performed according to Wang et al. (2007).

Statistical analysis

All data were analyzed using SPSS software (ver. 17.0) and presented as means ±SE for each treatment ($n = 3$, except in measurement of plant height, leaf number, and the mass fraction of ash, where $n = 10$). Differences among means were determined by Tukey's multiple range test. P values less than 0.05 were considered statistically significant.

Result

Plant growth under salt stress. Injury of *N. tazetta* L. seedlings was observed more

often in the leaf apex under substrate salinity and salt spray. The growth in the salinity group was generally worse than in the control group. In the 200 mM NaCl substrate salinity treatment, the growth of new leaves in *N. tazetta* L. seedling was severely limited and disease spot distributed in the leaf apex of old leaves. In the 300 mM NaCl substrate salinity treatment, leaves turned yellow, whereas in the 300 mM NaCl salt spray treatment, the growth of new leaves in *N. tazetta* L. seedling was severely limited and disease spot distributed in the leaf apex of young leaf. Injury of *N. tazetta* L. under salt spray was lower than under substrate salinity at the 300 mM NaCl treatment level (Table 1).

The mass fraction of ash under salt stress. With increasing salinity, the mass fraction of ash in *N. tazetta* L. seedling leaves under substrate salinity was higher than those in the control group ($P < 0.05$; Figs. 1 and 2). Under the same salinity, the mass fraction of ash in the distinct parts of leaves was as follows: leaf apex > leaf middle > leaf margin. The mass fraction of ash in the different ages of leaves under substrate salinity was as follows: old leaf > mature leaf > young leaf. The mass fractions of ash in the different ages of leaves under salt spray were as follows: young leaf > mature leaf > old leaf. The ash content under substrate salinity was greater than that under salt spray when plants were treated with 300 mM NaCl ($P < 0.05$). SPSS covariance analysis results showed that there was significant effect for ash in the factors of salinity, leaf partition, and leaf age, but there was no interaction effect between them.

The mass concentrations of Ca^{2+} , Mg^{2+} , Na^+ , K^+ , and Cl^- under salt stress. Increasing salinity increased the mass concentrations of Na^+ , K^+ , Mg^{2+} , and Cl^- in *N. tazetta* L. seedling leaves ($P < 0.05$). Different leaf parts (leaf margin, leaf apex, and leaf middle) exhibited variation in the distribution of each element, which was statistically significant ($P < 0.05$; Fig. 3). Under substrate salinity, Na^+ , K^+ , Cl^- , and Mg^{2+} are distributed in the leaf apex, whereas Ca^{2+} is mainly distributed in the leaf middle and leaf margin. Under salt spray, Mg^{2+} and Ca^{2+} are mainly distributed in the leaf middle and leaf margin, whereas Na^+ , K^+ , and Cl^- are mostly distributed in the leaf apex. Under substrate salinity and salt spray, the mass concentrations of Na^+ and Cl^- rapidly increased in all leaf parts with the

increase in salinity. However, the mass concentration of Ca^{2+} exhibited little alteration. The mass concentrations of Na^+ and Cl^- in the leaf parts of *N. tazetta* L. seedling leaves were significantly higher than the levels in the control group. The mass concentrations of K^+ , Mg^{2+} , and Ca^{2+} were lower than those in the control group. The concentrations of Na^+ and Cl^- under salt spray were greater than those under substrate salinity at the 300 mM NaCl treatment level.

Increasing salinity increased the mass concentrations of Na^+ , K^+ , Mg^{2+} , and Cl^- in *N. tazetta* L. seedling leaves ($P < 0.05$). Age of leaf (old leaf, mature leaf, and young leaf) also affected the distribution of each element in the seedling leaves ($P < 0.05$; Fig. 4). In the control group, Na^+ , K^+ , and Cl^- were mostly distributed in young leaves, Mg^{2+} was mainly distributed in mature leaves, and Ca^{2+} was mainly distributed in old leaves. Under 100 and 200 mM NaCl substrate salinity treatments, Na^+ and Cl^- were mostly distributed in the young leaves. However, Na^+ and Cl^- were mostly distributed in the old leaves in the 300 and 400 mM NaCl substrate salinity treatment groups. Under substrate salinity, K^+ was mostly distributed in the young leaves, Mg^{2+} was mostly distributed in the mature leaves, and Ca^{2+} was mostly distributed in the old leaves. The mass concentrations of Na^+ and Cl^- in the various age groups of *N. tazetta* L. seedling leaves were higher than those in the control group, the mass concentrations of K^+ and Mg^{2+} were lower than those in the control group, and the mass concentration of Ca^{2+} exhibited no significant difference. Under the salt spray treatment, Na^+ , K^+ , and Cl^- were mostly distributed in the young leaves, Mg^{2+} was mostly distributed in the mature leaves, whereas Ca^{2+} was mostly distributed in the old leaves. The mass concentrations of Na^+ and Cl^- in the various age groups of *N. tazetta* L. seedling leaves subjected to salt spray were higher than those in the control group, whereas the mass concentrations of Mg^{2+} , K^+ , and Ca^{2+} were lower than those in the control group. The concentrations of Na^+ , K^+ , and Cl^- under salt spray were lower than those under substrate salinity at the 300 mM NaCl treatment level.

One-Way analysis of variance analysis was completed using SPSS V10.0, the results show that under the two methods of salt stress there is the extremely significant strong

Table 1. Effects of salt stress on the growth of *N. tazetta* seedlings.

NaCl concn/(mm)	Plant ht/cm	Number of leaves	Growth situation	Symptoms of plant stress
Control	52.347 ± 0.587 a	11.323 ± 0.421 a	Well	No disease spot
100	51.325 ± 0.346 a	9.422 ± 0.341 b	Well	No disease spot
200	49.769 ± 0.231 b	7.853 ± 0.315 c	Slow	Disease spot distribute in the leaf apex of old leaf
300	40.653 ± 0.467 c	6.068 ± 0.479 d	Stop	Leaf turn yellow
400	32.032 ± 0.364 d	4.586 ± 0.652 d	Stop	Wither
300*	50.215 ± 0.211 a	8.215 ± 0.211 bc	Slow	Disease spot distribute in the leaf apex of young leaf

The data are expressed as means ±SE of 10 replications. Different letters show significant differences ($P < 0.05$). * stands for processing salinity of the salt spray group, and no mark stands for processing salinity of the substrate salinity group.

positive correlation on the mass concentrations of Na^+ and Cl^- in *N. tazetta* seedlings (Pearson correlation coefficient was 2.647, $P < 0.01$). There were extremely significant weak positive correlations between the mass concentrations of Na^+ and ash, Ca^{2+} and ash, and Cl^- and ash in *N. tazetta* seedlings (Pearson correlation coefficients of 0.547, 0.613, and 0.571, respectively; $P < 0.01$). There were extremely significant weak negative correlations between the mass concentrations of Na^+ and K^+ , K^+ and Cl^- , Na^+ and Ca^{2+} , Na^+ and Mg^{2+} , Ca^{2+} and Cl^- , and K^+ and ash in *N. tazetta* seedlings (Pearson correlation coefficients of -0.652 , -0.312 , -0.543 , -0.203 , -0.456 , and -0.129 , respectively; $P < 0.01$). There were significant weak negative correlations between the mass concentrations of K^+ and Ca^{2+} in *N. tazetta* seedlings (Pearson correlation coefficient of -2.482 , $P < 0.05$).

Under substrate salinity and salt spray, the ratios of K^+/Na^+ in the different leaf parts and age groups were significantly lower than

those in the control group (Tables 2 and 3; $P < 0.05$). The ratio of K^+/Na^+ decreased with increasing salinity. The pattern of K^+/Na^+ ratios in the distinct parts of the leaf was as follows: leaf middle > leaf margin > leaf apex. Under substrate salinity, the ratios of K^+/Na^+ in the different age groups of leaves decreased as follows: young leaf > mature leaf > old leaf, whereas under salt spray, the ratios of K^+/Na^+ in the different age groups of leaves decreased as follows: mature leaf > old leaf > young leaf. When they were treated with 300 mM NaCl, the ratio of K^+/Na^+ was lower under substrate salinity than that under salt spray.

Discussion

Salt spray comes from the ocean, and the composition of salt spray is similar to that of seawater. It has been reported that chloride is the ion with the highest concentrations in sea water, and chloride accounts for almost 90% of the total salt. *N. tazetta* L. are mainly distributed near the ocean on coniferous islands. The salinity of sea water is nearly 350 mM NaCl, and the concentration of NaCl in the atmosphere is close to 300 mM on average. In this experiment, the

quality fraction was 300 mM NaCl for salt spray.

Salt spray affects the growth of the plants by affecting the absorption ability of the leaf, and substrate salinity affects the growth of the plants through permeability and transportation in the roots. The mass concentrations of Ca^{2+} , Mg^{2+} , Na^+ , K^+ , and Cl^- in *N. tazetta* L. seedlings changed with the salt stress treatments. However, the salt redistribution in plants manifests in different ways depending on whether the stress is from salt spray or substrate salinity. Under substrate salinity, the salt was absorbed by the roots from the culture media. The salt was then transported from the stem to leaf through the xylem; therefore, a large amount of Na^+ is deposited at the apex of the leaf by transpiration (Tavakkoli et al., 2011). Under salt spray stress, leaves absorb the salt from the salt fog. The apex of the leaf acts as the absorption point, and the salt in the seedling leaves is therefore more concentrated in the leaf apex than in the margin or the middle. Therefore, the salt injury symptoms first begin to appear in the leaf apex under substrate salinity and salt spray. This is consistent with previous studies (Munns and Tester, 2008). In the young

Fig. 1. The changes of ash content in the parts of *Narcissus tazetta* leaf with substrate salinity. Note: The error bars represent standard error (SE) of mean of 10 replications. Different normal letters within the same NaCl concentration represent significant difference among the age and parts of *N. tazetta* leaf at the 0.05 level. * stands for processing salinity of the salt spray group, and no mark stands for processing salinity of the substrate salinity group.

Fig. 2. The changes of ash content in the age of *Narcissus tazetta* leaf with substrate salinity. Note: The error bars represent standard error (SE) of mean of 10 replications. Different normal letters within the same NaCl concentration represent significant differences among the age and parts of *N. tazetta* leaf at the 0.05 level. * stands for processing salinity of the salt spray group, and no mark stands for processing salinity of the substrate salinity group.

Fig. 3. The changes of the mineral elements in the parts of *Narcissus tazetta* leaf by the two salt stress pathways. Note: The error bars represent standard error (SE) of mean of three replications. Different normal letters within the same NaCl concentration represent significant differences in the parts of *N. tazetta* leaf at 0.05 level. * stands for processing salinity of the salt spray group, and no mark stands for processing salinity of the substrate salinity group.

leaves, Na^+ and Cl^- were the most concentrated under the salt spray treatment, and these ions were mostly concentrated in the old leaves under the substrate salinity treatments. This demonstrates that the young leaves were the most sensitive to salt under the salt spray treatment, whereas the old leaves were most sensitive to salt under substrate salinity. This is consistent with previous studies (Sun et al., 2010).

The key ion related to resistance to salt stress is K^+ (Shinozaki and Dennis, 2003). It is the most abundant cation in higher plants, and it also plays important roles in physiological functions, such as regulation of ion balance, osmotic regulation, protein synthesis,

maintenance of cell turgor pressure, and photosynthesis. The ionic radii of K^+ and Na^+ are similar to that of hydrated energy, and K^+ and Na^+ have competition with absorption sites and active sites, thus inhibiting the enzyme activity and metabolic process of K^+ (Shabala and Cuin, 2008). Higher K^+ content and a higher ratio of K^+/Na^+ can reduce the injury due to salt stress (Maathuis and Amtmann, 1999). We found differences in the ratios of K^+/Na^+ in the different age groups and parts of the leaf. These differences are due to ion selectivity. In the leaf apex of *N. tazetta* L. seedlings under both salt stress, in the old leaves under the substrate salinity treatments, and in the young leaves

under the salt spray treatment, the ratio of K^+/Na^+ is smaller, the selectivity of K^+ is less, the selectivity of Na^+ is greater, and the ion balance ability of K^+/Na^+ is weak. Therefore, the salinity is mainly distributed in the leaf apex of old leaves under the substrate salinity treatments; the salinity is mainly distributed in the leaf apex of young leaves under the salt spray treatments. The ratio of K^+/Na^+ in the different parts of the leaf was greater under the salt spray treatment than in the substrate salinity treatments at the 300 mM NaCl treatment level. Therefore, the ion toxicity on *N. tazetta* L. seedlings was more serious under substrate salinity than under salt spray treatments. This is not consistent with previous studies (Mahlooji et al., 2017; Megan, 2006; Ogura and Yura, 2008).

Salt levels that exceed a certain concentration can cause injury to the plant, but low salt levels can promote plant growth (Zolla et al., 2010). There was a significant positive correlation between the mass concentrations of Na^+ and Cl^- in the experimental treatments of *N. tazetta* L. seedlings, which is consistent with previous studies (Amini et al., 2017; Munns and Tester, 2008). The mass concentrations of Na^+ and Cl^- exhibited a very high similarity among the different ages and parts of *N. tazetta* L. seedling leaves. Wang and Lin (1999) studied the distribution of plant nutrients in *Kandelia candel*, *Bruguiera gymnorhiza*, and *Rhizophora stylosa* during the process of plant leaf senescence. The mass concentrations of Cl^- in three mangrove plant leaves were similar to that of Na^+ , and there was a significantly positive linear correlation between the mass concentrations of Na^+ and Cl^- (Wang and Lin, 1999). Under substrate salinity and salt spray treatments, the mass concentrations of Na^+ and Cl^- in *N. tazetta* L. seedlings increased significantly, whereas other elements were not notably affected. Thus, the mass fraction of ash in the seedlings under salt stress was also increased. This may be an adaptation to salt stress via the production of more organic osmoregulation substances. The mass concentrations of Na^+ and Cl^- were significantly increased by the two methods of salt stress, causing ion poison. In terms of ion poisoning, salt injury is mainly an Na^+ effect or a Cl^- effect. However, the determination of the dominant

Fig. 4. The changes of the mineral elements in the age of *Narcissus tazetta* leaf by the two salt stress pathways. Note: The error bars represent standard error (SE) of mean of three replications. Different normal letters within the same NaCl concentration represent significant differences in the age of *N. tazetta* leaf at the 0.05 level. * stands for processing salinity of the salt spray group, and no mark stands for processing salinity of the substrate salinity group.

Table 2. Effects of salt stress on the ratios of K^+/Na^+ in the different parts of leaf.

	Control	100 mm	200 mm	300 mm	300 mm*	400 mm
Leaf margin	7.7811 ± 0.35 a	1.0519 ± 0.17 de	0.8625 ± 0.12 f	0.8464 ± 0.13 f	0.8892 ± 0.08 f	0.7744 ± 0.11 g
Leaf middle	6.5803 ± 0.43 b	1.0917 ± 0.22 d	0.9364 ± 0.18 ef	0.9171 ± 0.17 ef	0.9473 ± 0.13 ef	0.8091 ± 0.15 fg
Leaf apex	4.0532 ± 0.32 c	0.9861 ± 0.18 e	0.8473 ± 0.13 f	0.7172 ± 0.12 gh	0.8574 ± 0.09 f	0.7607 ± 0.08 g

The data are expressed as means ± SE of three replications. Different letters show significant differences ($P < 0.05$). * stands for processing salinity of the salt spray group, and no mark stands for processing salinity of the substrate salinity group.

Table 3. Effects of salt stress on the ratios of K^+/Na^+ in the different ages of leaf.

	Control	100 mm	200 mm	300 mm	300 mm*	400 mm
Young leaf	6.5275 ± 0.38 c	1.0613 ± 0.19 e	0.9381 ± 0.16 f	0.9152 ± 0.12 fg	0.8559 ± 0.03 gh	0.8040 ± 0.08 h
Mature leaf	7.3243 ± 0.41 b	1.3422 ± 0.20 d	0.9431 ± 0.20 f	0.9095 ± 0.11 fg	0.9434 ± 0.04 f	0.7244 ± 0.07 h
Old leaf	7.7516 ± 0.28 a	1.0592 ± 0.23 e	0.9164 ± 0.27 g	0.7298 ± 0.22 i	0.8872 ± 0.02 g	0.6227 ± 0.14 j

The data are expressed as means ± SE of three replications. Different letters show significant differences ($P < 0.05$). * stands for processing salinity of the salt spray group, and no mark stands for processing salinity of the substrate salinity group.

ion in this process is still an open research question.

Conclusion

Salinity could be a major influencing factor on leaf growth in *N. tazetta* L. seedlings. Under substrate salinity and salt spray, the leaf disease areas of *N. tazetta* L. seedlings are more concentrated in the leaf apex. Growth in the salinity treatment groups is generally worse than that in the control group. The mass fraction of ash and the mass concentrations of Ca^{2+} , Mg^{2+} , Na^+ , K^+ , and Cl^- were generally greater in the salinity groups than in the control. The concentrations of all five ions (Ca^{2+} , Mg^{2+} , Na^+ , K^+ , and Cl^-) also increased with increasing salinity, especially in the leaf apex. Meanwhile, under the same salinity, the ion concentrations are lower in the salt spray treatments than in the substrate salinity treatments. This indicates that substrate salinity could induce more injury to the leaf. The results of this investigation suggest that salinity may induce injury and limit the growth of *N. tazetta* L. seedlings. These findings should benefit the artificial cultivation of this plant.

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