

Effects of exogenous IAA on the growth and physiological characteristics of Chinese cabbage seedlings under salt stress

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Abstract: A pot experiment was conducted to study the effects of the growth and physiological characteristics by spraying 5 different concentrations (0, 50, 100, 150, 200 μ mol/L) of indoleacetic acid (IAA) on leaves in Chinese cabbage seedlings which under salt stress. The result showed that IAA significantly promoted the growth and increased the biomass of Chinese cabbage seedlings under salt stress. It also enhanced the capacity of osmotic adjustment and antioxidant capacity, protecting the structure and function of cell membrane. Therefore, IAA can alleviate the damage of Chinese cabbage seedlings under salt stress, and the most suitable concentration is 150 μ mol/L. The seedlings which spraying 150 μ mol/L exogenous IAA compared with the control, the fresh weight of aerial part increased by 19.82%, the total dry weight increased by 18.74%, CAT enzyme activities increased by 45.66%, the chlorophyll content improved by 29.49% .

Introduction

Chinese cabbage (*Brassica rapa ssp. pekinensis*) is an important leafy vegetable [1]. Because of its rich nutrient, rich in sugars, protein and vitamins, it is popular with consumer and is the first in the area of Chinese vegetable cultivation.

Soil salinization is a world-recognized resource and ecological problem, China's salt land area accounts for about 1/3 of Asia [2]. The salt is mainly caused damage in plant by osmotic stress, ion poisoning and oxidative stress [3-4]. Guo Rui and other studies found that the main damage of salt stress to flax was osmotic stress and ion toxicity, and the ionic balance of flax cells was broken [5].

IAA is a class of auxins, which plays an important role in the elongation and differentiation of plant cells [6-7]. Wei Aili has been found application of exogenous IAA, the growth of soybean seedlings under salt stress was significantly promoted, and biomass increased, and the photosynthetic capacity and antioxidant capacity increased [8]. Through to the strawberry test tube seedlings were treated with exogenous 6-BA and IAA under salt stress. Zheng Pingsheng Found that the salt stress was reduced and the growth of strawberry test tube seedlings was promoted, and the membrane lipid peroxide decreased [9]. Park found that IAA plays a central role in the resistance of plants, therefore, it is speculated that IAA plays an important role in regulating the physiology of cabbage seedlings under salt stress, which can improve its salt tolerance and promote the growth of plants [10].

In recent years, it has become more and more attention and research to use exogenous IAA to improve crops resistance, which has become a hot spot in plant resistance research [11]. The effects of exogenous IAA on the growth index, chlorophyll content and physiological indexes under salt stress were studied in the experiment. The mechanism of IAA alleviation of salt stress in Chinese cabbage seedlings was clarified, and the best concentration of IAA was selected to provide the theoretical basis for the research and production practice of Chinese cabbage.

Materials and Methods

Materials. The variety of Chinese cabbage is the "kuaike 35F" were purchased from Chengdu Jinbaisheng farming co. Ltd. IAA purchased from Beijing Suolaibao Technology Co, Ltd.

Experimental design. The experiment was conducted in Institute of Pomology and Olericulture, Sichuan Agricultural University from March to May, 2016. Select full Chinese cabbage seeds, Use 10% phosphate trisodium solution to disinfect for 10 minutes, then rinse repeatedly with distilled water and then wrap it in wet gauze for germination. After the seeds were exposed, sown in 10 cm × 10cm (diameter × height) nutrition bowl (vermiculite: perlite = 1: 1, V/V), Culture in a plastic shed. When two cotyledons unearthed, watering with Hoagland nutrient solution every two days, every bowl of water 20ml. When the two leaves are unfolded, Switch to Hoagland nutrient solution containing 50 mmol·L⁻¹ NaCl every 2 days, and 20 mL of water per bowl until the experiment has been over.

When the three leaves of Chinese cabbage seedlings were unfolded, the Chinese cabbage seedlings with uniform growth were selected, the leaves were sprayed with 0μmol·L⁻¹ (CK, treated with water), 50μmol·L⁻¹, 100μmol·L⁻¹, 150μmol·L⁻¹, 200μmol·L⁻¹ of IAA solution, once every 2 days, each time 20ml, Sprayed 3 times, and each treatment was 3 pots, 3 per pot, the determination of the indicators after 30 days.

Statistic analyses. Using Excel 2010 for data recording and finishing, SPSS was used for statistical analysis, compare of different significance using Duncan's new multiple range method.

Results and analyzes

Growth and biomass. It can be seen from table 1, that with the increase of IAA concentration, the plant height, stem diameter, root length and fresh weight of aboveground of cabbage seedling increased first and then decreased, and were higher than CK. when the IAA concentration reached 150 μmol·L⁻¹, the indexes reached the maximum, The fresh weight of aboveground, root length, plant height and stem diameter were respectively increased by 19.82%, 55.70%, 13.14% and 37.12% by the control. Under the treatment of exogenous IAA, there were no significant differences in the plant height of Chinese cabbage under 100 μmol·L⁻¹ and 200 μmol·L⁻¹, the other treatments of concentration all were different significance.

Table 1 Effects of exogenous IAA on the growth of Chinese cabbage seedlings under salt stress

IAA concentration /($\mu\text{mol}\cdot\text{L}^{-1}$)	Shoot fresh weight /($\text{g}\cdot\text{plant}^{-1}$)	Root length /(cm)	Plant height /(cm)	Stem diameter /(cm)
0 (CK)	4.051±0.03 e	16.48±0.85 e	8.22±0.08 d	0.264±0.01 e
50	4.392±0.03 d	21.00±0.51d	8.60±0.07c	0.302±0.01 d
100	4.623±0.05b	23.44±0.74 b	9.10±0.17 b	0.345±0.01 b
150	4.854±0.12a	24.66±0.56 a	9.30±0.16a	0.362±0.02 a
200	4.503±0.03c	22.18±0.51 c	9.16±0.20b	0.318±0.01 c

Note: The data followed by different lowercase indicate significant difference of 5% level, the same as follow tables.

Dry weight. As can be seen from Table 2, that cabbage seedlings were sprayed with exogenous IAA which aboveground, root system, whole plant dry weight and water content of the aboveground are significantly higher than CK. And that with the increase of IAA concentration, the above four indexes and root / shoot ratio, the resistance coefficient increased first and then decreased, at the $150\mu\text{mol}\cdot\text{L}^{-1}$ to obtain the maximum, compared with the control increased by 8.43%, 28.10%, 18.74%, 2.15%, 18.18%, 19.00% respectively.

Table 2 Effects of exogenous IAA on dry weight of Chinese cabbage seedlings under salt stress

IAA concentration /($\mu\text{mol}\cdot\text{L}^{-1}$)	Shoot dry weight /($\text{g}\cdot\text{plant}^{-1}$)	Root dry weight /($\text{g}\cdot\text{plant}^{-1}$)	Total dry weight /($\text{g}\cdot\text{plant}^{-1}$)	Shoot water content /%	Root-shoot ratio	Resistance coefficient
0 (CK)	0.747±0.01 e	0.822±0.03 e	1.569±0.01e	81.56±0.01 e	1.10	1.00
50	0.756±0.01d	0.892±0.01d	1.648±0.02d	82.79±0.03 d	1.18	1.05
100	0.790±0.03b	0.972±0.01b	1.762±0.03 b	82.91±0.01 b	1.23	1.12
150	0.810±0.02 a	1.053±0.02 a	1.863±0.03 a	83.31±0.02 a	1.30	1.19
200	0.773±0.04c	0.955±0.01c	1.728±0.01 c	82.83±0.05c	1.24	1.10

Antioxidant enzyme activity, the contents of osmotic adjustment substance and MDA. As was known from table 3, the activity of antioxidant enzymes of Chinese cabbage seedlings was significantly higher than CK under the effect of exogenous IAA. The activities of CAT, SOD, POD and Soluble protein content in Chinese cabbage seedlings increased first and then decreased with the increase of IAA concentration, and it was up to the maximum under the $150\mu\text{mol}\cdot\text{L}^{-1}$, compared with the control increased by 45.66%, 31.61%, 18.43%, 24.84% Respectively. There was no significant difference in CAT activity under the $100\mu\text{mol}\cdot\text{L}^{-1}$, $150\mu\text{mol}\cdot\text{L}^{-1}$, $200\mu\text{mol}\cdot\text{L}^{-1}$ of IAA concentration. POD activity was no significant difference at $100\mu\text{mol}\cdot\text{L}^{-1}$, $200\mu\text{mol}\cdot\text{L}^{-1}$ of IAA concentration. SOD activity was no significant difference in the others concentrations except the $150\mu\text{mol}\cdot\text{L}^{-1}$. Compare with the control, there was no significant difference in soluble protein content at IAA concentration $50\mu\text{mol}\cdot\text{L}^{-1}$ and $100\mu\text{mol}\cdot\text{L}^{-1}$. MDA content was no significant

difference at $150 \mu\text{mol}\cdot\text{L}^{-1}$, $200 \mu\text{mol}\cdot\text{L}^{-1}$ of IAA concentration.

Table 3 Effects of exogenous IAA on antioxidant enzyme activity, the contents of osmotic adjustment substance and MDA of Chinese cabbage seedlings under salt stress

IAA concentration $/(\mu\text{mol}\cdot\text{L}^{-1})$	CAT activity $/(\text{U}\cdot\text{g}^{-1}\text{FW})$	POD activity $/(\text{U}\cdot\text{g}^{-1}\text{FW})$	SOD activity $/(\text{U}\cdot\text{g}^{-1}\text{FW})$	Soluble protein content $/(\text{mg}\cdot\text{g}^{-1}\text{FW})$	MDA content $/(\text{nmol}\cdot\text{g}^{-1}\text{FW})$
0 (CK)	21.9±0.42 c	1930±5.66d	162.84±4.67b	4.79±0.19c	9.48±0.14a
50	25.2±1.13 b	2102±69.30 c	165.26±4.18b	4.84±0.10c	8.86±0.11b
100	29.8±0.42a	2345±29.70b	171.14±2.68b	5.35±0.15c	8.12±0.15c
150	31.9±1.13a	2540±74.95 a	192.86±2.38 a	5.98±0.20a	7.42±0.13d
200	29.4±0.71a	2282±22.63 b	166.30±3.40b	5.33±0.13b	7.24±0.12d

Photosynthetic pigment content. From Table 4, it was found that chlorophyll a, chlorophyll b, chlorophyll total content and chlorophyll a and chlorophyll b were significantly higher than that of CK, except for the concentration of $50 \mu\text{mol}\cdot\text{L}^{-1}$. After treatment of exogenous IAA, With the increase of exogenous IAA concentration, the indexes increased first and then decreased, and reached the maximum at $150 \mu\text{mol}\cdot\text{L}^{-1}$ of IAA concentration, compared with the control increased by 21.67%, 23.20%, 29.49%, 6.18% respectively. The carotenoid content of each treatment increased first and then decreased, and reached the maximum at $100 \mu\text{mol}\cdot\text{L}^{-1}$, which was 10.34% higher than that of CK ($P < 0.05$).

Table 4 Effects of exogenous IAA on the contents of photosynthetic pigments of Chinese cabbage seedlings under salt stress

IAA concentration $/(\mu\text{mol}\cdot\text{L}^{-1})$	Chlorophyll a content $/(\text{mg}\cdot\text{g}^{-1})$	Chlorophyll b content $/(\text{mg}\cdot\text{g}^{-1})$	Total chlorophyll content $/(\text{mg}\cdot\text{g}^{-1})$	Chlorophyll a/b	Carotenoid content $/(\text{mg}\cdot\text{g}^{-1})$
0 (CK)	0.526±0.01c	0.125±0.006c	0.651±0.02 c	4.21±0.02c	0.203±0.007b
50	0.546±0.01c	0.127±0.008c	0.673±0.02c	4.30±0.03bc	0.210±0.008ab
100	0.640±0.01b	0.145±0.009b	0.785±0.01b	4.41±0.08ab	0.224±0.006 a
150	0.689±0.01a	0.154±0.008a	0.843±0.02 a	4.47±0.03 a	0.219±0.006ab
200	0.628±0.01b	0.142±0.004 b	0.770±0.01b	4.42±0.04ab	0.215±0.006ab

Conclusion

The results showed that IAA could increase the plant height and promote root growth and differentiation, increased the quality of dry matter on the ground significantly, alleviated the damage of Chinese cabbage significantly, this is consistent with the findings of Mclord et al[12]. The results also showed that exogenous IAA could increase the root/shoot ratio of Chinese cabbage seedlings under salt stress and increase the resistance coefficient, and improve the ability of root to absorb soil water and minerals, so as to improve the water content in the upper part, maintain the osmotic

balance, improve cabbage Seedlings salt resistance.

Salt stress causes free radical accumulation, cell membrane lipid peroxidation increased, to promote the accumulation of large amounts of MDA, destruction of cell membrane structure and function, protein synthesis was inhibited, which cause damage to plants, and even death. Soluble proteins play a role in osmotic regulation of plants, SOD, POD, CAT is the main antioxidant enzyme, by scavenging free radicals, mitigating adversity et.al and protection of plant cell membrane. The results of this experiment show that, The optimum concentration of IAA could increase significantly the antioxidant enzyme activity and soluble protein content of Chinese cabbage seedlings under salt stress, and reduce significantly the MDA content, thus protecting the cell membrane structure and function. The effect of auxin on the resistance index of tomato seedlings under salt stress which results is the same with Liu shuanheng[13].

The studied found that salt stress destroyed the chloroplast structure of plants, and the accumulation of reactive oxygen free radicals destroyed chlorophyll, which resulted in the weakening of photosynthetic capacity of plant. Carotenoids also have the role of quencher of reactive oxygen and prevent cell membrane lipid peroxidation. This experiment showed that the suitable concentration of exogenous IAA could increase the photosynthetic pigment content significantly and increase the photosynthetic capacity of Chinese cabbage seedlings under salt stress, so as to improve the salt tolerance of Chinese cabbage.

In summary, the growth of Chinese cabbage seedlings was promoted significantly under the salt stress by foliar spraying suitable concentration range of exogenous IAA and the biomass was increased. The activity of antioxidant enzymes in cabbage seedlings increased significantly, the level of membrane lipid peroxidation decreased, the content of soluble protein increased, the ability of cell osmotic adjustment was enhanced, the normal metabolism of cells was maintained, and the photosynthetic pigment content was increased. Thereby, damage of salt stress was slowed. The effect of exogenous IAA on the physiological indexes and resistance indexes of Chinese cabbage seedlings under salt stress which manifestation was promoted, and with IAA concentration increased first and then weakened, When the concentration of IAA was $150\mu\text{mol}\cdot\text{L}^{-1}$, the treatment was the best.

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