Advances in Engineering Research (AER), volume 143
6th International Conference on Energy and Environmental Protection (ICEEP 2017)

Effect of Spraying Indoleacetic acid on Physiological Characteristics of Aluminum Stress of Chinese cabbage seedlings

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Key words: Indoleacetic acid; aluminum stress; physiological characteristics

Abstract. A pot experiment was conducted to study the effects of spraying leaves of Chinese cabbage seedlings with different concentrations of indoleacetic acid (IAA) on the physiological characteristics of Chinese cabbage seedlings under aluminum stress. The results showed that, spraying IAA could increase photosynthetic pigment content, such as chlorophyll a, chlorophyll b and carotenoid. When the concentration of IAA was 200 μmol·L^{-1}, the contents of SOD, POD, CAT and soluble protein were 17.85%, 20.70%, 40.63% and 22.56% higher than CK respectively, which indicated that spraying IAA could alleviate the effect of aluminum on plant physiology system destruction, and promote the growth and development of plant tissue. The 200 μmol·L^{-1} was the best.

Introduction

Chinese cabbage is a common cruciferous plant which is rich in minerals and vitamins. In South China, Chinese cabbage is also widely cultivated in the acidic soil[1]. Chinese cabbage is easy to store and transport, is one of the most productive vegetables[2]. In Southeast Asia, Japan, the United States and Europe and other countries have also widely introduced cultivation, which has gradually become a worldwide cultivated vegetables[3].

Aluminum is one of the most abundant metal elements in the earth's crust, under acidic conditions (PH<5), the insoluble aluminum in the soil will be transformed into soluble aluminum, which can cause damage to plants[4]. In recent years, with the increasingly serious environmental acidification and the repeated erosion and evaporation of acid rain on soil, leading to the content of aluminum in soil has increased continuously[5]. Therefore, aluminum toxicity has become an important factor limiting plant growth, especially in acidic soils[6].

Indoleacetic acid, a main form of natural plant auxin, belongs to a kind of indole and is the first to find a class of hormones to promote plant growth[7]. It is believed that aluminum is the main reason to inhibit the growth and division of plant root tip cells, and auxin as a signal transmission, directly involved in the process of aluminum poisoning[8].Wang Ping and others research shows that, spraying IAA could alleviate the growth toxicity of black soybean roots under aluminum stress,

and a certain concentration of IAA could promote cell elongation growth[9]. In recent years, studies have been found that IAA also plays an important role in improving plant abiotic stress,such as Zn, Pb and other stress, spraying IAA could increase the height and aboveground biomass of maize,promote plant root growth, and significantly alleviate the toxic effects of heavy metals on plants[10]. Ouzounidou and Ilias studies of sunflowers indicate that, 100 μmol·L^{-1} IAA could effectively alleviate[11].

However, the influence of temperature stress, salt stress and aluminum stress on the cultivation of Chinese cabbage is becoming more and more serious. Therefore, in this experiment, the effects of spraying leaves of Chinese cabbage seedlings with different concentrations of IAA on the physiological characteristics of Chinese cabbage seedlings under Aluminum stress were studied, in order to provide some reference for the production and the application.

Materials and Methods

Materials. Chinese cabbage varieties 'quick 35', the seeds of Chengdu Jin Bo Sheng Seed Industry Co., Ltd. production. Indoleacetic acid was purchased from Sigma company.

Experimental design. Select the seeds of Chinese cabbage, sterilization soaking germination.When the seeds were white seeded in nursery pots(10 cm × 10 cm) with perlite and vermiculite (perlite: vermiculite = 1: 1). Watering once a day until the cotyledons unearthed, then watering Hoagland nutrient solution (water volume of 20 ml/pot) every 2d. After the two leaves of the Chinese cabbage were fully expanded, the seedlings were transplanted to pots filled with medium. The size of the pots was 21 cm × 20 cm (diameter × height). The pots were placed in plastic greenhouses and grown under natural conditions, and once every 2d watering 50 mmol·L^{-1} $AlCl_3$ Hoagland nutrient solution for aluminum treatment until the end of the trial, in order to prevent water shortages, according to weather conditions appropriate to add water. After the 3 leaves of the Chinese cabbage were fully expanded sprayed with IAA solution of 0, 50, 100, and 200 μmol·L^{-1} at 9:00 once every 2d, Sprayed three times, and each treatment was repeated three times. 30 d after the determination of the indicators.

Statistic analyses. Statistical analyses were performed using SPSS 13.0 statistical software (IBM, Chicago, IL, USA). Data were analyzed by one-way ANOVA with least significant difference (LSD) at a 5% confidence level.

Results and discussion

Biomass. As shown in Table 1, with the increase of IAA concentration, root fresh weight, root dry weight, shoot fresh weight, shoot dry weight that all increased. At the concentration of 200 μmol·L^{-1}, the highest reached. At 100, 150 and 200 μmol·L^{-1} concentrations, root fresh weight, root dry weight, shoot fresh weight and shoot dry weight were significantly higher than those of CK. When the concentration was 50 μmol·L^{-1}, the aboveground fresh weight and shoot dry weight were not significantly different from those of CK.

Table 1 Effect of spraying IAA on the biomass of Chinese cabbage seedlings under aluminum stress

IAA (μmol·L^{-1})	root fresh weight (g.plant^{-1})	root dry weight (g.plant^{-1})	shoot fresh weight (g.plant^{-1})	shoot dry weight (g.plant^{-1})
0	3.33±0.08b	0.89±0.01c	0.69±0.01b	0.17±0.02c
50	3.61±0.20b	0.98±0.01bc	0.71±0.01b	0.20±0.01bc
100	3.95±0.1ab	1.01±0.02b	0.74±0.01ab	0.22±0.01b
150	4.14±0.1a	1.12±0.02ab	0.86±0.02a	0.24±0.02ab
200	4.23±0.01a	1.20±0.01a	0.94±0.04a	0.25±0.01a

Note: there is a significant difference between 0.05 levels of different letters, the same asfollowing tables.

Growth. As shown in Table 2, plant height, root length, stem diameter and leaf area increased with the increase of IAA, and the concentration was the best at 200 μmol·L^{-1}. When the concentration of IAA was 50 μmol·L^{-1}, the indexes were not significantly different from CK, When IAA is 200 μmol·L^{-1}, there was significant difference compared with CK. With the increase of IAA concentration, the leaf area also increased when the concentration of IAA reached 200 μmol·L^{-1}, compared with the concentration of 0, 50 and 100 μmol·L^{-1}, the difference was significant.

Table 2 Effect of spraying IAA on the growth of Chinese cabbage seedlings under aluminum stress

IAA (μmol·L^{-1})	Plant height (cm)	Root length (cm)	Stem diameter (cm)	leaf area (cm^2)
0	9.16±0.02c	19.98± 0.03c	0.27±0.01c	134.80±3.5c
50	9.35±0.1bc	21.13±0.03c	0.29±0.01c	140.61±1.8bc
100	9.68±0.1b	21.59±0.04bc	0.30±0.02bc	161.50±11.9b
150	9.89±0.05ab	22.43±0.03bc	0.31±0.02ab	201.27±20.7ab
200	10.51±0.3a	23.23±0.10a	0.33±0.01a	229.34±6.9a

Note: there is a significant difference between 0.05 levels of different letters, the same asfollowing tables.

chlorophyll content. As shown in Table 3, spraying IAA could significantly increase the photosynthetic pigment content of Chinese cabbage seedlings leaves under aluminum stress, Chlorophyll a, chlorophyll b, total chlorophyll and carotenoid content increased with the increase of IAA concentration. When the concentration of IAA was 200 μmol·L^{-1}, it reached the maximum and was significantly different from CK. The content was 36.6%, 37.29%, 42.89% and 71.42% higher than CK. When the concentration of IAA was 100 and 150 μmol·L^{-1}, chlorophyll a, chlorophyll b, total chlorophyll and carotenoid were not significantly different from CK.

Table 3 Effect of spraying IAA on the chlorophyll content of Chinese cabbage seedlings under aluminum stress

IAA (μmol·L^{-1})	chlorophyll a (mg·g^{-1})	chlorophyll b (mg·g^{-1})	carotenoid (mg·g^{-1})	total chlorophyll (mg·g^{-1})
0	0.500±0.04c	0.098±0.02c	0.177±0.02c	0.587±0.1c
50	0.569±0.1bc	0.123±0.01bc	0.204±0.008bc	0.693±0.01bc
100	0.610±0.03ab	0.131±0.02bc	0.216±0.001ab	0.739±0.04ab
150	0.655±0.02ab	0.153±0.01ab	0.232±0.02ab	0.807±0.03ab
200	0.683±0.05a	0.168±0.002a	0.243±0.002a	0.851±0.01a

Note: there is a significant difference between 0.05 levels of different letters, the same asfollowing tables.

The enzymatic antioxidant system. As shown in Table 4, with the increase of IAA concentration, the activity of SOD, POD and CAT increased, while the content of MDA decreased accordingly. When the concentration of IAA was 200 μmol·L^{-1}, SOD, POD, CAT and soluble

protein were significantly different, which were 17.85%, 20.70%, 40.63% and 22.56% higher than CK. With the increase of IAA concentration, the enzyme activity was also increased. At 200 μmol·L^{-1}, the activity of each enzyme was the most obvious.

Table 4 Effect of spraying IAA on the enzymatic activity of Chinese cabbage seedlings under aluminum stress

IAA (μmol·L^{-1})	SOD (U·g^{-1})	POD (U·g^{-1})	CAT (U·g^{-1})	MDA (nmol/g)	soluble protein (mg·g)
0	163.68±4.12c	2096±82.21c	17.72±2.03c	12.241±1.25a	5.63±0.1c
50	168.02±1.01bc	2192±87.05c	20.25±0.1bc	10.130±0.02ab	5.86±0.05c
100	182.55±3.53b	2244±92.25bc	23.13±1.01b	9.100±1.02bc	5.99±0.01b
150	187.32±1.03ab	2308±94.51ab	24.92±0.9ab	8.827±0.1bc	6.21±0.5ab
200	192.91±3.02a	2530±112.04a	29.43±3.85a	7.451±1.01c	6.90±0.02a

Note: there is a significant difference between 0.05 levels of different letters, the same asfollowing tables.

Discussion

Exogenous spraying of IAA in a certain range can effectively alleviate the damage of physiological characteristics of aluminum stress cabbage seedlings. In the range of 0~200 μmol·L^{-1}, the biomass and growth of Chinese cabbage increased with the increase of IAA. Under aluminum stress, spraying IAA can increase the photosynthetic pigment content of the leaves, increase the activities of antioxidant enzymes POD, CAT and SOD, decrease the content of MDA and maintain the balance of active oxygen metabolism of Chinese cabbage seedlings, thus decreasing the damage of Chinese cabbage seedlings under aluminum stress. The treatment with 200 μmol·L^{-1} IAA was the best.

Reference

[1] L.Xiao, L.B.Sun and F.G.Sui: Journal of Plant Nutrition and Fertilizer Vol. 14 (2008), p. 608-612 (In Chinese).
[2] H.M.Cui and Z.Chen: Journal of Anhui Agricultural Sciences Vol. 34(2006), p. 4680-4682 (In Chinese).
[3] X.Y.Wang, S.C.Yu and F.L.Zhang: Journal of North China Agricultural University Vol. 23(2008), 97-103.
[4] J.H.Weng, L.F.Huang and X.R.Liu: Journal of Chinese Environmental Science Vol. 06(2000), p.501-505.
[5] C.L.Guo, L.Wang and S.H.Wen: Journal of Northwest Botanical Sciences Vol. 33(2013).
[6] Y.Chen: Journal of Southwest University Vol. 2012.
[7] W.M.Ni, X.Y.Chen and Z.H.Xu: Journal of Botany Vol. 03(2000), p.221-228.
[8] D.M.Wu, H.P.Cao and H.Shen: Journal of Plant Physiology Vol. 2014, p.1135-1143.
[9] P. Wang, Q.Chen and D.J.Chen: Journal of Soybean Science Vol, 05(2013), p.650-654.
[10] J.M.Zhou, Z.Dang and N.C.Chen: Journal of Environmental Science Vol. 28(2007), p. 2085-2088 (In Chinese).
[11] Ouzounidou G and Ilias I: Biologia Plan tarum. 49(2005), p.223-228.