Exploration of ecological benefits of *Conyza canadensis* — analysis and evaluation of the effects of *Conyza canadensis* water extract on the salt tolerance to maize at seed germination

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Abstract. Soil salinization is becoming increasingly severe and has emerged as a significant abiotic stress factor affecting crop yields. In order to investigate the role of *Conyza canadensis*'s allelopathic in alleviating salt-induced damage to crops and fostering salt-tolerant varieties, this study examined some indicators of maize seed germination during three levels of salt stress treatments (0, 150, 300 mmol/L) and three concentrations (0, 30, 60 g/L) of *Conyza canadensis* water extract (CCE). The results demonstrate that the application of CCE enhances the germination rate and germination energy of maize seeds under salt stress conditions. In addition, CCE significantly promotes main root length and stem height development in maize with salt-free stress. Moreover, CCE supplementation increased the chlorophyll content of maize exposed to various salt concentrations. Evaluation showed that low concentrations of CCE facilitated seed germination and improved salt tolerance at all levels of salinity, while high concentrations of CCE enhanced seed germination and salt tolerance at high salinity. Therefore, *Conyza canadensis* showed good ecological benefits in improving the salt-tolerant ability of maize during germination.

Keywords: Salt Stress, Salt Tolerance, *Conyza Canadensis* Water Extract, maize.

1 Introduction

The issue of soil salinization is becoming increasingly severe and has become a common resource and ecological problem around the world [1]. Soil salinization has negative effects on plants and has become one of the important abiotic stress factors affecting crop yields. Consequently, investigating the salt-tolerant mechanisms of crops and cultivating salt-tolerant varieties have become focal points of current research [2,3].

Conyza canadensis is a prevalent weed in the agricultural ecosystem of China. Due to its allelopathic effect and pioneer plant characteristics, *Conyza canadensis* has been extensively utilized in ecological restoration, medical medication [4,5]. However, there

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exists a research gap regarding the resistance of *Conyza canadensis*'s allelochemicals towards plants. Maize *(Zea mays* L.) is the largest food crop in China and plays an important role in agricultural production and food security. To investigate the allelopathic effects of *Conyza canadensis* on seed germination period and seedling growth of crops under salt stress, this study focused on maize as the subject and investigated the physiological responses under different salt treatment induced by *Conyza canadensis* water extract (CCE). The findings aim to provide a theoretical foundation for understanding the impact of *Conyza canadensis* on crops in saline-alkali soil.

2 Materials and method

2.1 Preparation of Conyza canadensis water extract

The extracts were prepared from the aboveground parts of fresh seedlings of *Conyza canadensis*. The plants were taken from abandoned agricultural land in the campus and are well-grown.

After the preparation of CCE mother liquor [6], it was stored in the refrigerator (4°C). The experiment utilized deionized water to prepare CCE of 30 and 60g/L concentrations, as required for the experimental procedures.

2.2 Plant materials and Seed Germination

The experiment was carried out from April to May in 2023. Crop seeds purchased from the seed station. The maize variety is Zhengdan 958.

The seeds were immersed in deionized water for 5 minutes. Subsequently, the seeds were sown onto a culture dish covered with two layers of filter paper and placed in a constant temperature incubator set at 27 °C for light avoidance cultivation.

A total of nine treatments were set up (Table 1). Each treatment was set up in 3 parallel groups, each with 30 seeds. A consistent volume of treatment solution was regularly replenished daily.

Table 1. The treatments

Treatment Groups	Treatments	Salt Concentration (mmol/L)	Extract Concentration (g/L)	Ratios
A	CK1	0	0	1:1
	T1-1	0	30	1:1
	T1-2	0	60	1:1
B	CK2	150	0	1:1
	T2-1	150	30	1:1
	T2-2	150	60	1:1
C	CK3	300	0	1:1
	T3-1	300	30	1:1
	T3-2	300	60	1:1

2.3 Measurement of the germination indicators

The number of germination was counted every day, and the germination rate (GR) and germination energy (GE) were calculated.

$$GR = \frac{G_7}{N} \times 100\% \tag{1}$$

$$GE = \frac{G_4}{N} \times 100\% \cdot\cdot \tag{2}$$

In these equations, T is the number of days, G_4 and G_7 are the total number of seeds germinated on the 4th and 7th days, respectively, and N is the total number of seeds.

On the 10th day, chlorophyll, main root length and stem height of the plants were measured. The chlorophyll was extracted with dimethylformamide (DMF) [7].

2.4 Evaluation of seed germination and growth ability

Seed germination and growth capacity are evaluated using the membership function method of fuzzy mathematics. The method calculates the membership function values (MFVs) of each measured indicator in each treatment. The mean values each of them were obtained in order to evaluate the germination ability comprehensively [8,9]. The higher the mean value, the greater the salt tolerance.

The membership function values for salt tolerance are calculated as follows.

$$X(\mu) = \frac{X\text{-}X_{MIN}}{X_{MAX} - X_{MIN}} \tag{3}$$

Here, $X(\mu)$ is the membership function value of the μth indicator, while X is the measured value of an indicator, and X_{MAX} and X_{MIN} represent the maximum and minimum value of the indicator, respectively.

2.5 Data analysis

Data were expressed as means ± standard error (SE). Statistical analyzes of significant differences were performed using SPSS Version 16.0 software, One-Way ANOVA, Duncan test ($P<0.05$).

3 Results and analysis

3.1 Germination rate and germination energy

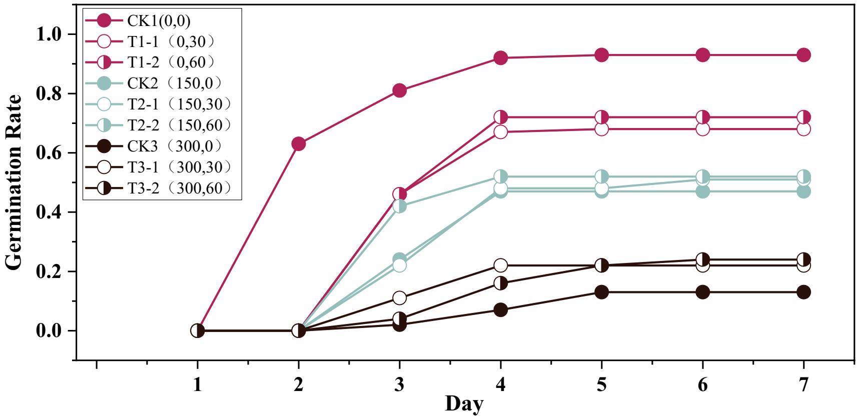

Fig. 1. The germination rate of maize in different treatments

Table 2. The germination energy of maize in different treatments

Treatments	CK	T1	T2	T3	T4	T5	T6	T7	T8
Germination Energy	0.92	0.67	0.72	0.47	0.48	0.52	0.07	0.22	0.16

Fig.1 and Table 2 show GR and GE of maize under different treatments respectively. As can be seen from Fig. 1, under water conditions (CK1), maize germination commenced on the second day, whereas the remaining eight treatments exhibited germination on the third day. As the culture duration progressed, a gradual increase in GR was observed across all treatments, with no further change in germination count after the sixth day.

Combined with Fig. 1 and Table 2, it can be seen that under each treatment condition, the GR and GE of the maize in water are the highest. As the salt concentration increased, the GR and GE decreased. In addition, the GR and GE of maize under salt stress conditions was higher when CCE were added compared to single salt stress alone, indicating that CCE significantly improved the germination ability of maize under salt stress.

3.2 Main root length and stem height

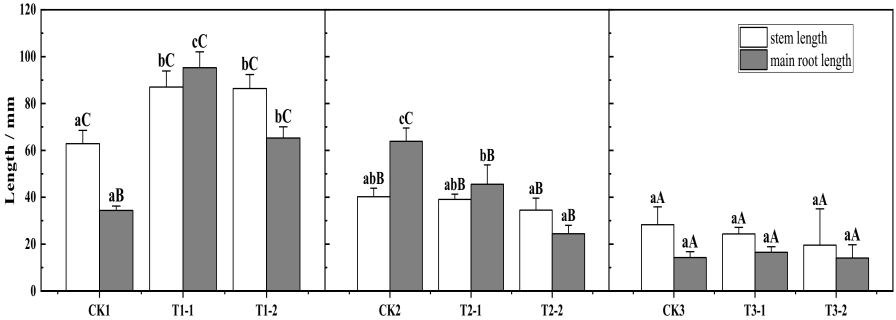

Fig. 2. The main root length and stem height of maize in each treatment. The lowercase letters in the figure represent the significance of differences within each treatment group (Group A, Graph A; Group B, Graph B; Group C, Graph C), and the uppercase letters represent the significance of differences between each treatment group (no salt (CK1, CK2, and CK3); low-salt (T-1, T2-1, and T3-1); high-salt (T1-2, T2-2, and T3-2)), with n=3 to 8. The same as below.

Figure 2 shows the changes of main root length and stem height of maize under each treatment. Under salt-free stress (Fig.2, A), different concentrations of CCE significantly enhanced the growth of main root length and stem height in maize, with lower concentrations of CCE exhibiting a more pronounced effect in promoting main root length. At low salt stress (Fig.2, B), the addition of CCE did not significantly affect stem height, but the main root length showed a significant response. The higher the CCE concentration, the shorter the main root length. This suggests that CCE has a more pronounced effect on root development in maize at low salt stress conditions.

Under the same CCE concentration treatment with different salt concentrations, the growth of stem height and main root length of crops was significantly inhibited by salt concentration.

3.3 Chlorophyll content

As can be seen from Fig.3, the chlorophyll content of maize leaves exhibits a significant decrease under salt stress (Fig.3, B and C). However, the addition of CCE significantly enhanced the chlorophyll content of maize. Under salt-free stress (Fig. 3, A), the higher the concentration of CCE, the more obvious increasing of chlorophyll content. Under salt stress, low concentration of CCE significantly increased the chlorophyll content of plants.

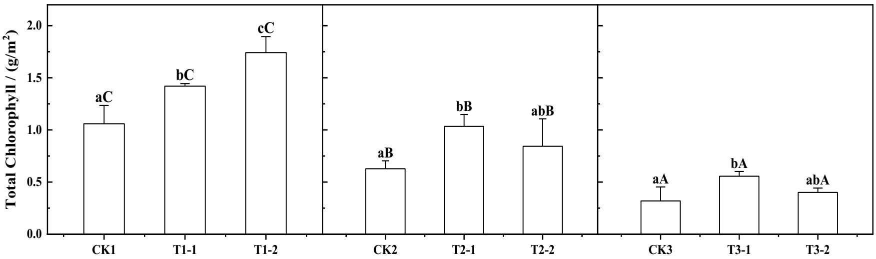

Fig. 3. The chlorophyll content of maize in different treatments

3.4 Evaluation

Table 3. Membership function values of seed germination ability

Treatment Groups	Treat-ments	MFV of GR	MFV of Stem height	MFV of Main root length	MFV of Total Chlorophyll	Mean MFVs
A	CK1	0.975	0.617	0.271	0.519	0.596
	T1-1	0.688	0.891	0.903	0.730	0.803
	T1-2	0.738	0.884	0.592	0.919	0.783
B	CK2	0.425	0.360	0.577	0.266	0.407
	T2-1	0.475	0.347	0.387	0.504	0.428
	T2-2	0.488	0.295	0.168	0.392	0.336
C	CK3	0.000	0.224	0.063	0.085	0.093
	T3-1	0.113	0.180	0.086	0.224	0.150
	T3-2	0.138	0.126	0.060	0.133	0.114

Table 3 shows the evaluation results and average values of each indicator at germination and seedling stage of maize in each treatment. As can be seen from Table 3, the evaluation results of each index are consistent with the variability characteristics of the measured indexes. Mean MFVs (Table 3) were the mean values of all indicator evaluation data under each treatment. It has been shown that the germination of maize seeds can be decreased by salt,but improved by CCE at all concentrations except low concentrations of CCE.

4 Discussion

The effect of CCE on the germination period of maize shows different characteristics in different indexes. When there is no salt stress, CCE has only a negative effect on the germination rate. However, once the seeds germinate, various plant indexes (root length, stem height, chlorophyll) are significantly higher compared to plants cultured in water. Under salt stress conditions, CCE promotes both the germination rate and potential in maize seeds at different salt concentrations, while also significantly increasing chlorophyll content. Previous studies have explored the positive effects of allelopathy on crop growth and salt tolerance improvement [10,11]. The allelopathy in *Conyza canadensis* plays a positive role in salt tolerance in this study.

Under low salt stress, CCE had no effect on stem, but main root length decreased by 28.72% (T2-1) and 61.77% (T2-2), respectively. At high salt stress, CCE showed a slight effect on main root length and stem height. This indicates that CCE has a more obvious effect on root under low salt stress, while salt plays a dominant role in limiting root growth under high salt stress.

Through evaluation, it is known that, with the exception of low salt + high CCE treatment (T2-2), the incorporation of CCE can enhance the germination capacity or salt tolerance of maize seeds in each treatment, which is consistent with previous findings by Wang et al. on CCE [6].

5 Conclusion

The addition of low CCE significantly improved the germination ability and salt tolerance of maize seeds. The addition of high CCE significantly improved the germination of maize seeds at high or no salt stress.

Although *Conyza canadensis* has some limitations on GR of maize seeds with salt-free stress, upon comprehensive evaluation, *Conyza canadensis* is able to reflect a better positive effect regardless of the presence of salt stress, demonstrating the positive ecological effect of *Conyza canadensis*.

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