IOP Conf. Series: Materials Science and Engineering **730** (2020) 012054 doi:10.1088/1757-899X/730/1/012054

Effects of Atrazine on the Growth of *Suaeda Heteroptera*

Yujie Huo[2,3], Haifeng Wei [1,2,3*],Yumeng Zhao [2,3],Jie He [2,3] and Mingliang Zhang [2,3]

[1]Dalian Ocean University, Key Laboratory of Mariculture& Stock Enhancement in North China's Sea, Ministry of Agriculture and Rural Affairs, Dalian 116023, China.
[2]Dalian Ocean University, School of Marine Science and Environment Engineering, Dalian 116023, China.
[3]KeyLaboratory of Coastal Marine Environmental Science and Technology of Liaoning Province, Dalian 116023, China.
Email: weihaifeng@dlou.edu.cn

Abstract: To explore the ecological degradation of *Suaeda Heteroptera* in Panjin Red Beach wetland, the effects of Atrazine on the growth and physiological effects of *Suaeda Heteroptera* seedlings were studied by indoor hydroponics. Experimental results show that the leaves and roots of the *Suaeda Heteroptera* seedlings are very sensitive to Atrazine. And the LD_{50} of the number of leaves of *Suaeda Heteroptera* seedlings were 34.2 μg/L. At low concentrations (3.8-11.4 μg/L), Atrazine promoted the growth of seedling leaves; at higher concentrations (22.8-34.8 μg/L), it inhibited leavse growth and had a significant dose-effect relationship Atrazine had different effects on height and root length of *Suaeda Heteroptera* , but had no effect on seedlings stem length. The formation of chlorophyll b in leaves of *Suaeda Heteroptera* treated by Atrazine was inhibited. Also, the main factor for the decrease of total chlorophyll consent is Atrazine.

Atrazine is a triazine pesticide and is a selective herbicide. Its chemical properties are relatively stable and can only be hydrolyzed by heating in acidic or alkaline media [1]. Atrazine is one of the most easily produced triazenyl benzenes. Because Atrazine is easy to synthesize, cost-effective and effective, it has become the herbicide with the highest utilization rate among farmers [3].

The *Suaeda Heteroptera* community is a major component of wetland and a dominant species of coastal tidal flats. Since 2000, it has begun to show significant degradation, and unexplained deaths have led to a reduction in their community area. Although Chinese scholars have carried out some research on the causes of the degradation of the *Suaeda Heteroptera*, there are still many shortcomings in the current research. In the early on-site monitoring, a variety of herbicides were found in the water and soil of the growing area of *Suaeda Heteroptera*. Therefore, studying the effect of Atrazine on the growth of *Suaeda Heteroptera* has important practical significance for further revealing the cause of its degradation. [4]

1. Materials and Methods

1.1. Materials

The seeds of *Suaeda Heteropteraare* from the coastal beach of Panjin, Liaoning Province. The seawater is taken from the sand-filtered seawater in the Blackstone reef of Dalian. Atrazine, produced by Hefei Jiuyi Agricultural Development corporation, the active ingredient is 38%. Plant growth nutrient solution.

1.2. Methods

1.2.1. Test method

Before the experiment, 10 seedlings (18 groups) were selected, and the seedlings of *Suaeda Heteroptera* were vigorously tested. The data of seedling height (8-10 cm), stem length (2.5-3.5 cm), root length (2.5-3.5 cm), number of leaves (10-12), and number of roots (6-8) were recorded. According to the investigation of the use of pesticides in the Red Beach wetland. Set 5 groups of Atrazine concentration (3.8, 11.4, 19, 22.8, 26.6, 34.2 μg/L). Three replicates per treatment were performed in a 100 ml glass beaker. Place in a well-ventilated and well-lit place at room temperature to ensure that the seedlings can grow normally. The experiment time is two weeks.

1.2.2. Determination of indicators

1.2.2.1. Plant height, stem length, root length, number of leaves, number of roots

On the 3rd, 8th and 11th day, the plant height, stem length and root length of the seedlings were measured with a scale. The number of leaves and the number of roots were recorded by counting method. (plant height: full length from the bottom of the main root to the top of the blade; stem length: from the bottom of the last pair of blades to the root; root length: from the root to the bottom of the main root.)

1.2.2.2. Determination of chlorophyll content

Grind the seedlings with a grinder and put them into a 10 ml test tube, then add 6 ml of 95% alcohol solution and heat in a 75 ℃ water bath for 5 min to complete the extraction. After filtration, dilute to 10 ml colorimetric tube with 95% alcohol solution. Measured with a 752N UV-Vis spectrophotometer.

Calculation formula:

Chlorophyll a concentration: $\mathrm{C\,a} = 13.95\,\mathrm{A\,665} - 6.88\,\mathrm{A\,649}$

Chlorophyll b concentration: $\mathrm{C\,b} = 24.96\,\mathrm{A\,649} - 7.32\,\mathrm{A\,665}$

Chloroplast pigment content:

$$\text{Chloroplast pigment content}(\mathrm{mg/g}) = \frac{(\mathrm{C\,a} + \mathrm{C\,b}) \times \text{Extract volume V} \times \text{Dilution factor}}{\mathrm{m}}$$

1.2.3. Data Statistics and Processing

The experimental data was analyzed by SPSS 20.0 and Excel statistical software. One-way ANOVA was performed with SPSS 20.0, and the Ducan method was used for comparison. The significance level was set to 0.05.

2. Results

2.1. Effects of Atrazine on Plant Height, Stem Length and Length of Main Roots of Suaeda Heteroptera

As can be seen from Figure 1, the 11th day, the Atrazine solution with a concentration of 3.8-26.6 μg/L had no significant effect on the plant height growth of the seedlings, and the paired T test method ($P>0.05$) showed no significant difference. At the concentration of 34.2μg/L, the plant height of the seedlings was significantly different from that of the control group ($P<0.05$), indicating that the high concentration of Atrazine solution significantly inhibited the plant height growth of the seedlings. There was a significant dose-effect relationship between Atrazine and plant height, $y = -0.1252x + 11.772$, $R^2 = 0.8926$.

As can be seen from Figure 2, When the concentration of Atrazine was 3.8-34.2 μg/L, the stem length of seedlings fluctuated in a small range, and there was no significant difference ($P>0.05$).

As can be seen from Figure 3, the 11th day, when the concentration of Atrazine was 3.8-19 μg/L, the root length of the seedlings of Suaeda Heteroptera fluctuated within a small range, ($P>0.05$). At the concentration of 26.6—34.2μg/L, there was a significant difference between the root length of the seedlings and the control group, and there was a significant dose-effect relationship between Atrazine concentration and root length, $y=-0.0825x+4.2292$, $R2 = 0.8368$.

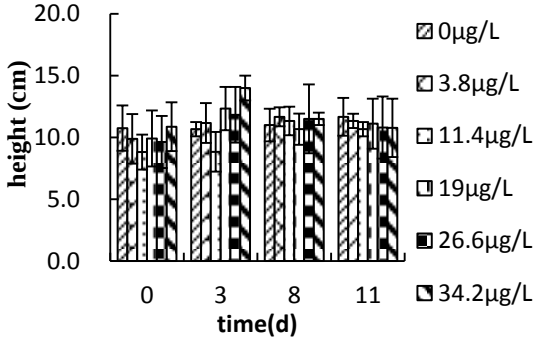

Figure 1. Effect of Atrazine on the height of *Suaeda Heteroptera*

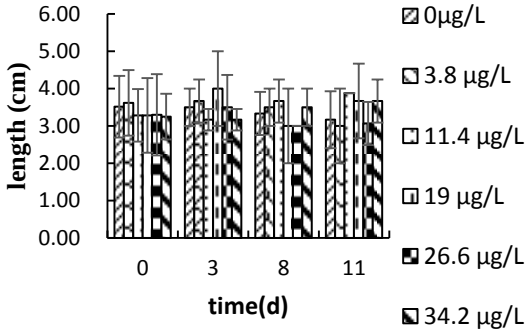

Figure 2. Effect of Atrazine on stem length of *Suaeda Heteroptera*

2.2. The Effect of Atrazine on the Number of Leaves and Roots of Suaeda Heteroptera

The effect of Atrazine on the growth of *Suaeda Heteroptera* was directly reflected in the changes in the number of leaves and roots. According to the number of leaves and roots, the extent of the effect of Atrazine on the growth of *Suaeda Heteroptera* was determined. The effects of Atrazine on the leaves and roots of *Suaeda Heteroptera* are shown in Figures 4, 5.

As can be seen from Figure 4, on the 11th day showed obvious changes. When the concentration of Atrazine was 11.4 – 19 μg/L, the number of leaves was not significantly different from that of the control group ($P>0.05$). There was a significant dose-effect relationship between Atrazine concentration and leaf number between 26.6 and 34.2 μg/L, $y= -0.7161x+16.62$, $R^2 =0.7245$. The number of leaves decreased as the concentration increased ($P<0.05$), and there was a significant change at 34.2 μg/L, and the inhibition rate was 50%.

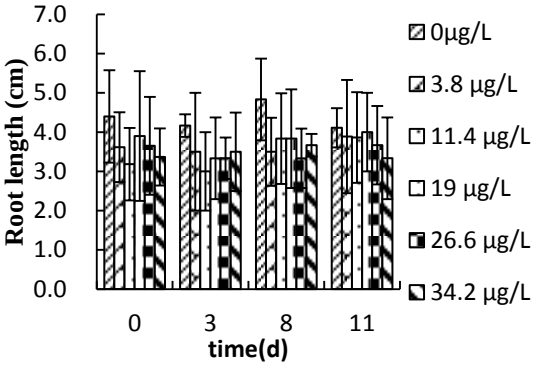

Figure 3. Effect of Atrazine on root length of *Suaeda Heteroptera*

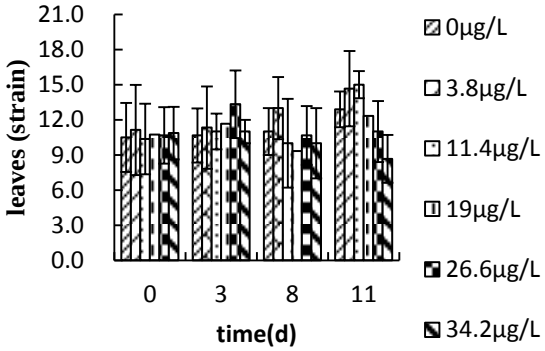

Figure 4. Effect of Atrazine on the Number of Leaves of *Suaeda Heteroptera*

Figure 5 shows that there is a clear gradient in the number of seedling roots on the 8th and 11th day, and the higher concentration of Atrazine the smaller the number of roots. At 11th day, when the concentration of Atrazine was 3.8 μg/L, the number of roots of seedlings was significantly different from that of the control group ($P<0.05$). And when the concentration of Atrazine was 11.4-38 μg/L, there was a significant change. There was a significant dose-effect relationship between the concentration of Atrazine and the number of roots. The correlation equations and coefficients were $y= -1.7758x+23$ and $R2=0.937$, respectively. The results showed that the concentration of Atrazine in the range of 3.8-38 μg / L had a significant inhibitory effect on the number of seedling roots, and the inhibition rate was 72%. The growth of the roots of Suaeda Heteropterais very sensitive to the concentration of Atrazine in the environment, so when the concentration of Atrazine exceeds 3.8 μg/L, it may cause slow growth or even death.

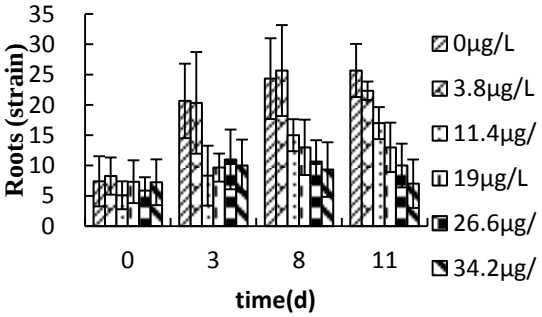

Figure 5. Effect of Atrazine on the Number of Roots of *Suaeda Heteroptera*

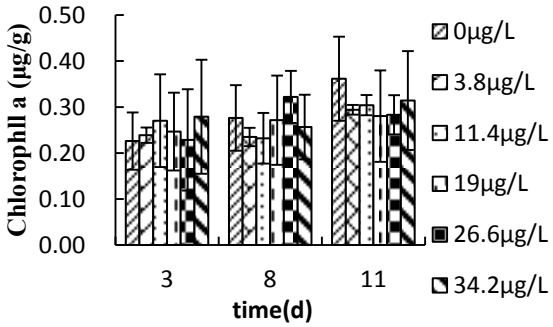

Figure 6. Effect of Atrazine on Chlorophyll a of *Suaeda Heteroptera*

2.3. Effects of Atrazine on Chlorophyll A and Chlorophyll B in Seedlings of Suaeda Heteroptera

As can be seen from Figure 6, Within the experimental concentration range (3.8-34.2 μg/L), there was no significant difference between the treatment group and the control group ($P>0.05$), indicating that Atrazine had no significant effect on the content of chlorophyll a in *Suaeda Heteroptera*.

It can be seen from the data in Figure 7, on the 11th day, the content of chlorophyll b in the seedlings showed a significant change trend. When the concentration of Atrazine was between 3.8-34.2 μg/L, the chlorophyll b content of the seedlings showed a downward trend. The chlorophyll b content was significantly different from that of the control group at 3.8-19 μg/L ($P<0.05$). At 26.6-34.2 μg/L, there was a significant difference between the two groups, and the inhibition rate was 57%. There was a significant dose-effect relationship between Atrazine concentration and chlorophyll b content, $y= -0.0315x+0.5563$, $R^2 =0.8107$, indicating that the Atrazine solution with a concentration of 3.8-34.2 μg/L had a significant effect on the content of chlorophyll b in the seedlings of S. salsa, which inhibited the synthesis of chlorophyll b.

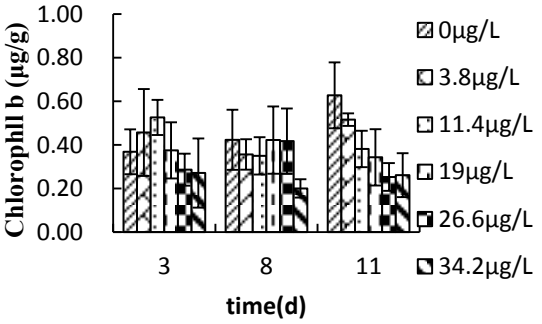

Figure 7. Effect of Atrazine on Chlorophyll b of *Suaeda Heteroptera*

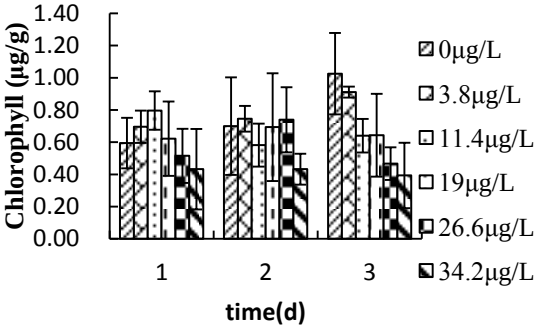

Figure 8. Effect of Atrazine on Chlorophyll of *Suaeda Heteroptera*

2.4. The Effect of Atrazine on the Total Chlorophyll Content of Suaeda Heteroptera

It can be seen from Figure 8 that there is a clear trend on the 11th day. When the concentration of Atrazine was 3.8-34.2 μg/L, the total chlorophyll content of *Suaeda Heteroptera* showed a significant downward trend. At the concentration of 3.8-19 μg/L, the total chlorophyll content of the seedlings was significantly different from the control group ($P<0.05$), and at the concentration of 26.6-34.2 μg/L, there was a significant change and the inhibition rate was 55%. There was a significant dose-effect relationship between Atrazine concentration and total chlorophyll content, $y= -0.0612x+1.0159$, $R^2 =0.9133$, indicating that the solution of Atrazine had a significant inhibitory effect on the chlorophyll synthesis of *Suaeda Heteroptera*.

From the appearance point of view, on the 14th day after treatment, when the concentration of Atrazine was 26.6-34.2 μg/L, the whole Suaeda Heteroptera showed atrophy, the leaves turned yellow, the rhizome showed bending and lodging, and gradually withered. At the concentration between 11.4 and 19 μg/L, the leaves in the lowermost layer showed atrophy. In summary, Atrazine has an inhibitory effect on the synthesis of chlorophyll in the seedlings of Suaeda Heteroptera. When the concentration of Atrazine was low, the degree of inhibition was small; and when the concentration exceeded 11.4 μg/L, a significant inhibitory effect was observed.

3. Discussion

3.1. Relationship Between Concentration of Atrazine and Growth Index of Suaeda Heteroptera

Low concentration of Atrazine had no significant effect on plant height, and high concentration inhibited the growth of *Suaeda Heteroptera*. Jinfeng Ma et al. pointed out that there was no significant difference between the experimental group and the control when the concentration of Atrazine was 1040-2080 g.a.i/hm^2. The plant height was basically consistent with the control. The low concentration of Atrazine had no significant effect on the emergence of medlar. The concentration of Atrazine reached 2460 g.a.i/hm^2 had a significant inhibitory effect on the plant height of the scorpion. This conclusion is consistent with the results of this experiment [5]. It indicated that when the plants were under the stress of Atrazine the photosynthesis electron transfer was blocked, and the formation of NADPH and ATP was reduced, which affected the carbon fixation and inhibited the normal growth of plants [6-9].

The concentration of Atrazine has a significant effect on the root growth of seedlings. Dandan Liu et al. found that when the Atrazine was 0.05 mg/L, there was no significant effect on the root growth of soybean seedlings. When the concentration of Atrazine was greater than 0.1 mg/L, the growth of radicle was significantly inhibited [10]. Under stress, the receptor protein in the plant transmits a stress signal, which produces a large amount of active oxygen, causing membrane lipid peroxidation and destroying the organelles, causing extracellular permeability of the cells, loss of electrolytes, increased conductivity, and inhibition of seedling growth.

Low concentration of Atrazine promoted the growth of seedling leaves and inhibited at high concentrations. Xianglin Liu et al. also showed that acetochlor can promote the plant height and root number of rice at low concentration. When the concentration of acetochlor reaches a certain value, it has a strong inhibitory effect on rice growth, and the root Inhibition is stronger than inhibition of stems [11], which is similar to the results of this experiment. At low concentrations, auxin promotes growth, while at high concentrations it inhibits plant growth. Higher concentrations cause plant death and can even act as herbicides [12]. In this experiment, the effect of Atrazine was similar to that of auxin.

3.2. Relationship Between Concentration of Atrazine and Physiological Indexes of Suaeda Heteroptera

Atrazine has no significant effect on chlorophyll a of *Suaeda Heteroptera*. There is a significant effect on chlorophyll b, showing a significant dose-effect relationship. The total chlorophyll content and the change trend of chlorophyll b were basically the same. The chlorophyll biosynthesis process consists of L-glutamyl-tRNA→chlorophyll a→chlorophyll b, which requires 15 steps of reaction involving 15 enzymes. The above experimental results show that the synthesis of chlorophyll a is not significantly affected, and the synthesis of chlorophyll b is inhibited, which may be caused by chlorophyll a to chlorophyll b. Atrazine affects the synthesis of certain enzymes [13]. Liu Jimin et al. showed that the chlorophyll content in cabbage leaves showed a significant downward trend compared with the control. There was a significant dose-effect relationship. There was a significant difference in the chlorophyll content between the control and the high concentration of Atrazine. There was no significant difference in the low concentration [14]. This conclusion is consistent with the

results of this test.

4. Conclusion

The effects of Atrazine on different parts of the seedlings of *Suaeda Heteropterawere* quite different. From the perspective of seedling growth, there are obvious rules for the variation of plant height, root length and root number of seedlings. When the concentration of Atrazine reaches a threshold, below this concentration, there is no obvious effect on the species, but above this concentration, an inhibitory effect is produced. However, in the experiment of seedling stem length change, the law is not obvious, and the growth difference at each concentration is not significantly obvious.

From the aspect of chlorophyll content, Atrazine had a great influence on the total consent of chlorophyll b and chlorophyll in seedlings, and its synthesis was obviously inhibited, and the linear relationship showed a continuous decreasing trend. There is no obvious rule for the content of chlorophyll a, and the difference is not obvious at each concentration. The low concentration of Atrazine solution promoted the leaves growth of the seedlings, and the high concentration inhibited the growth of the seedlings, indicating that the low concentration of Atrazine promoted the growth of the plants. It may be that the different parts of the Suaeda Heteropteraare different in sensitivity to Atrazine, so the threshold is also different.

5. References

[1] Changling Liu 2002 *World Pesticide Encyclopedia, Herbicide Roll* [M] (Chemical Industry Press)
[2] Yaoxun Qu 2015 *Comprehensive understanding of Atrazine* [J]. Today's pesticides (10): 23-24
[3] Jiayun Lu 2001 *Plant pathogenic mycology* [M]. (Agriculture Press)
[4] Yi Qiu and Ningzi Xie 2008 *Research progress on the harm and non-biodegradation of pesticide atrazine* [J] Guangdong Chemical Industry 35(1):73-77
[5] Jinfeng Ma et al. 2014 *The effect of atrazine on the morphology and physiological indexes of Gardenia seedlings* [J] Crop Jr. (4): 138-142
[6] Caihong Yang, Liand Feng, Xingshan Tian 2016 *Effects of soil residues from atrazine on growth and chlorophyll fluorescence parameters of four vegetables* [J] Chinese vegetables (3): 53-59
[7] Kulikova N A and Perminova I V 2002 *Binding of Atrazine to Humic Substances from Soil: Peat and Coal Related to Their Structure* [J] Environ Sci Techno1 36 (17): 3720–3724
[8] Piccolo A et al. 1998 *Atrazine Interactions with Soil Humic Substances of Different Molecular Structure* [J] J Environ Qua1 27: 1324–1333
[9] Kellly W R and Wilson S D 2000 *Movement of Bromide Nitrogen-15 and Atrazine Through Flooded Soils* [J]. J Environ Qual 29 (4): 1085–1094
[10] Liu Dandan et al. 2017 *Relief of the toxic effect of degrading bacteria on atrazine in the early stage of soybean growth* [J]. Soybean Science 36(6): 938-942
[11] Liu Xianglin et al. 2014 *Study on Sensitivity of Different Varieties of Rice to Acetochlor* [J]. Chinese Agricultural Science Bulletin 30(18): 209-213
[12] Gu Xiaohong et al. 2017 *Application of Plant Growth Regulators in the Growth and Cultivation of Medicinal Plants* [J]. Modern Chinese Medicine 19(2):295-305
[13] Wang Pingrong et al. 2009 *Research progress in chlorophyll biosynthesis of higher plants* [J]. Journal of Northwest Botanical Sciences 29(3): 629-636
[14] Liu Jimin et al. 2011 *The effect of atrazine on the growth and physiological effects of Chinese cabbage seedlings* [J]. Journal of Southern Agricultural Sciences 42(7): 752-755