Research Progress on Growth Characteristics of Invasive Plants in Different Habitats

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Abstract: Biological invasion generates serious threats to global biodiversity. Exotic species usually have high environmental adaptability and tolerance, which is one of the bases of their invasion. Except for biological invasion threats, other serious environmental problems like extreme cold or hot events, soil drought, saline-alkali and flood are emerging constantly on a global scale. In the background of multiple environmental problems interfering with existing habitats, exploring the growth characteristics of invasive plants in different habitats, and grasping the reasons why the invasive plants can obtain growth superiorities are in favor of propelling the understanding of their invasion mechanism. This paper gives an overview of research progress on the invasive plants' morphological characteristics and physiological characteristics in deferent habitats, summarizes the growth specialties of invasive plants which are affected by high temperature, low temperature, drought and flood, and discusses the reasons why the invasive plants prevail in the growth competitions, which provided theoretical and realistic signification to relieve the biological invasion current status.

1 Introduction

Since the industrial revolution, human beings have excessively exploited earth resources without protection, resulting in some environmental problems continue to occur. Global climate warming leads to more and longer-term extreme warm events. The situation of drought trend zone is even more terrible and the drought takes place frequently. Arid areas and semiarid areas are accompanied by soil salinization phenomenon [1], which severely affects crop growth and human life. In addition, there are regions where flood happens frequently and the climate fluctuates markedly. Since recent centuries, biological invasion problems have brought serious threats to gradually fragile ecosystems again.

Under environmental stress, because of their immobility, plants tend to relieve the damage that stress brings by transforming their morphological traits and physiological and biochemical processes. In the background of global habitats changing, researching plant growth characteristics is essential. One key to a successful invasion of invasive plants is their high tolerance to environmental conditions and relatively short lifecycle [2]. Under identical growth conditions, invasive plants often absorb more water and nutrient than indigenous plants. Under environmental stress, they have higher biomass and better metabolism. Comparing the growth situation of the invasive plants and its related close-up plants under adversity stress, which is beneficial to analyze the reasons why the invasive plants can acquire the growth advantages and clarify the invasion mechanisms, which have important practical significance.

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2 Biological invasion current status

As society develops and the trade of import and export raises, human activities and international express services have become new channels for exotic species to invade, and many exotic organisms are spreading worldwide. China is one of the countries damaged the worst by biological invasion in the world, Exotic invasive species are distributed in more than half regions of 31 provinces (autonomous region and municipality), which has a significant impact on the creatures security and social-economic development of China. The invasive species characteristics are represented in three aspects like many species and extensive sources, wide invasion area and continually enlarging invasion scale, and heavy potential damage [3]. China has a rich ecosystem, which is apt for exotic invasive species to inhabit and reproduce. Therefore, various types of biological invasions occur from vertebrates and invertebrates, terrestrial and aquatic plants, marine and freshwater organisms, to animal and plant bacteria and fungi [4]. The harm of Exotic invasive species is increasing without any saturation phenomenon. Currently, the threat of a new species invasion is faced every two or three years, and it is urgent to control biological invasion.

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3 Growth characteristics of invasive plants in different habitats

Plant growth is not only affected by their genetic material but also produces obvious differences as their habitats differ. Factors like temperature, moisture, nutritional status, and light play an important role in plant growth development. The environmental impacts on plants are considerable, such as plants grown in desert areas, whose roots will have a large average connection length to maintain their water absorption [5]. During long-term evolution, plants form complex regulatory networks to cope with different stresses and carry out adaptive growth by changing their morphological characteristics, physiological and biochemical metabolic processes, so as to maintain normal growth under environmental stresses. In this paper, starting from several influencing factors, factors the growth characteristics of invasive plants in different habitats are discussed.

3.1 Effect of temperature stress on the invasive plant growth

Temperature, as an important factor affecting the enzyme activity, regulates almost all enzymatic reactions, determines important physiological and biochemical processes such as respiration and photosynthesis, and exerts comprehensive effects on plants. Besides, temperature also acts as the motivation for biological function [6], which plays an important role in plant water potential adjustment and transpiration. Temperature stress can be subdivided into low-temperature stress and high-temperature stress. Under low-temperature stress, the growth and development of plants are significantly inhibited, the plant height is decreased, and the blades are decreased and shrunk. Chlorophyll synthesis is restrained and photosynthetic rate decreases. The selectivity of the cell membrane decreases, and the cell contents extravasate, which causes the dehydration of protoplasm. The activity of active oxygen scavenging enzymes declines and the massive accumulation of MDA and active oxygen brings further damage to membrane lipids or even leads to plant death in severe cases [7]. High-temperature stress can bring direct injuries and indirect injuries. When a plant is momentarily exposed to high temperature, it can cause "necrosis" due to protein denaturation and membrane lipid liquefaction induced by high temperature, which are direct injuries to plants [8]. Under high temperature, the partial pressure of oxygen in plant tissues is reduced, aerobic respiration is inhibited, and substances such as acetaldehyde and ethanol are accumulated, which is called indirect injuries to plants. Jiagang Si believed that respiration, as an oxidation process, had a role in the removal of oxygen free radicals in cells [9]. Under high-temperature stress, the activity of active oxygen scavenger enzymes is reduced, and cell respiratory oxidation is also reduced, which forces the accumulation of active oxygen free radicals, cell membrane lipid oxidation, biofilm system destruction and the extravasate of cell contents. The increase in the content of soluble proteins is an important way for plants to respond to stress, but under high temperature, the degradation of proteins is accelerated and their synthesis is hindered [10], finally resulting in unbalance and the inhibition of the normal plant growth.

Invasive plants respond to both high and low-temperature stress, and the response mechanism is significantly stronger than that of the native related plants. For example, under the simulated extreme high-temperature stress, for Wedelia trilobata, the time of high temperature caused its significant growth inhibition was 14 days later than native Wedelia chinensis, their plant height and biomass were also significantly higher than those of native Wedelia chinensis, and the net photosynthetic rate and stomatal conductance of Wedelia trilobata were higher than those of native Wedelia chinensis, which proved that the invasive Wedelia trilobata had stronger tolerance to high-temperature stress than native Wedelia chinensis. Its PSII maximum conversion efficiency of primary light energy decreased with the least amount, which meant that it suffered the least damage under high-temperature stress and had the strongest resistance to the stress [11]. The activities of SOD, POD, APX and MDAR of Chromolaena odorata were enhanced with the increase of temperature, and the antioxidant enzyme system played an important role in the process of plant stress resistance. The enhanced activity proved that Chromolaena odorata relatively had strong resistance to high temperature [12]. Similarly, the POD and CAT activities in Ambrosia artemisiifolia L. cells almost increased gradually with the increase of temperature under high-temperature stress [13]. Invasive plants also have a certain tolerance to low temperatures. The severe invasive plants Ipomoea cairica could still grow after the native close-up plants Ipomoea triloba have stoped growing, and its biomass reduction was less than that of Ipomoea triloba. The increase of proline and soluble sugar in the cells of Ipomoea cairica were significantly smaller than that of Ipomoea triloba, and the decrease of its cell membrane permeability was lower, as well as the accumulation of peroxide, proving that the cell membrane lipids of Ipomoea cairica were less damaged than those of Ipomoea triloba at the same low temperature. Also, the reduction in PSII maximum conversion efficiency of primary light energy was the smallest, which also indicated that it suffered the least damage [14]. Studies have shown that antioxidant enzyme activities of some plants had an increasing trend under high-temperature stress, but a decreasing trend under low temperature, such as cucumber [15] and the above-mentioned Chromolaena odorata and Ambrosia artemisiifolia L.; most of the invasive plants are sensitive to low temperature, and their resistance to high-temperature stress is stronger than that to low-temperature stress. Low-temperature stress may become a good way to control the expansion of invasive plants.

3.2 Effect of water stress on the invasive plant growth

Water factors affecting plants can be divided into drought

and waterlogging. Drought can cause stress in the whole process of plant growth, such as seed germination, vegetative growth, reproductive growth [16]. Waterlogging will also bring harm to plants' growth. Under drought stress, the plant tissue is dehydrated, and the leaves are curled and the stomatas are closed to reduce water loss and maintain the plant temperature; the activity of antioxidant system is reduced, and the accumulation of free radicals leads to the oxidation of cell membrane lipids, and then the cell membranes' structure and function change, which will result in the outflow of cell contents [17]. When a plant is flooded, the oxygen in the underwater part is insufficient, which intensifies anaerobic respiration and accumulates harmful substances. Carbon dioxide content of the water is relatively low, and the photosynthetic efficiency is seriously decreased [18]. Abscisic acid and other hormones are transmitted upward, which cause leaves premature senescence, and make leaves wither. Either severe drought or waterlogging can lead to plant death in serious cases.

Invasive plants are tolerant to drought. For example, under the PEG simulated drought condition, the leaf loss of Wedelia trilobata was less than that of native Wedelia chinensis, and the plant height and root length were greater than those of native Wedelia chinensis. Under natural drought conditions, the root length of Wedelia trilobata was greater than that of native Wedelia chinensis. The accumulated MDA content of Erigeron canadensis L. gradually increased with the drought going on. Besides, free proline and soluble protein began to accumulate in large amounts, and the osmotic potential was reduced and maintained stable. Superoxide dismutase activity tended to increase throughout the drought. In addition, after rehydration, PSII maximum conversion efficiency of primary light energy was overcompensated, indicating that they have stronger recovery ability. On the other hand, the survival rate of Alternanthera philoxeroides decreased gradually with the increase of waterlogging duration, and the higher the water level was, the faster the impact would be. With the waterlogging going on, the plant height and leaf length tended to increase, but the stem diameter and leaf width decreased. Alternanthera philoxeroides responded significantly to the waterlogging, and the waterlogging could effectively reduce its survival rate, which indicates that waterlogging may be a major method to control the severe invasion of Alternanthera philoxeroides [19]. Ambrosia artemisiifolia L.was treated with drought and waterlogging respectively. The intracellular MDA content under drought condition was higher than that under waterlogging condition, and the activities of SOD and POD under waterlogging condition were higher than those under drought stress. The less content of MDA and the high activity of antioxidant enzymes proved that Ambrosia artemisiifolia had a stronger adaptive regulation ability under waterlogging condition [13]. Under higher water level stress, Spartina alterniflora lost leaves and the chlorophyll content was decreased, but with the passage of time, the inhibition was gradually lifted and chlorophyll synthesis returned to normal. After the waterlogging stress was relieved, the growth of Spartina alterniflora recovered rapidly [20]. In general, under drought or waterlogging conditions, invasive plants can produce adaptive growth and their adaptability is generally stronger than that of the related native plants. The adaptability strengths and weaknesses under drought and waterlogging conditions need to be further studied. After the stress is relieved, invasive plants have better resilience, adaptability and resilience, which increases the successful invasion possibility of invasive plants.

4 Prospect

Biological invasion has become one of the five major global environmental problems in the 21st century. Studies have not found any saturation sign of the invasive species‘ increasing worldwide. Over time, most taxonomic groups even show an increase in the first-recorded-rate. Biological invasion still seriously affects the global environment, ecosystems' structural stability and functional stability, which further causes serious harm to human production and life, and brings huge losses to global agriculture, animal husbandry and economy. Understanding the morphological, physiological and biochemical responses of invasive plants when they under stress can help us master the mechanisms of biological invasion, and then find ways to alleviate the invasion.

At present, the response mechanisms of invasive plants under various stresses (such as temperature, moisture, nutrition, light, heavy metal and other influencing factors) have been studied. Exploring the stress resistance response of invasive plants from many aspects, more systematically and in detail researching the stress responses in morphology and physiological metabolism of invasive plants, which can help us master the growth characteristics of invasive plants, determine the environment that is not suitable for the growth of invasive plants, and promote the solution of biological invasion problem.

In addition to the single stress, it is necessary to impose various related stresses on invasive plants and judge the stress interaction effect. Much stress is generally associated. For example, saline-alkali stress is likely to occur in arid and semi-arid areas due to improper irrigation methods, and with the prolongation of waterlogging time, the possibility of heavy metal ion accumulation increases, which will cause heavy metal stress. It is more in line with the natural growth environment to simultaneously apply multiple stresses to invasive plants at the same time and based on this, we can get more practical results. Besides, China is still seriously affected by drought, and its saline-alkali land area ranks third in the world. in the background of the national water and soil environment, the research on the growth characteristics of invasive plants is more targeted, and can help us more easily master the reasons why invasive plants can obtain growth advantages in current environments.

Many studies have shown that it is very significant to compare the invasive plant responses to the same stress

factor in different forms. For example, in terms of temperature stress, the activities of CAT and POD of Chromolaena odorata gradually increased with the increase of temperature, but when they under low-temperature stress, their activities continuously decreased. In terms of water stress, the degree of membrane lipid oxidation of Ambrosia artemisiifolia L. was lower under drought stress than under waterlogging stress. Through such a comparison, we can find the conditions that the invasive plants are relatively intolerant to, and promote the mitigation of biological invasion problems. In addition, in the same habitat, finding out local plants which have more growth advantages than invasive plants will also help us to inhibit invasive plants' malignant growth. For example, under drought stress, the intracellular MDA content of indigenous plant Pueraria thomsonii Benth was lower than that of the invasive plant Mikania micrantha. When the stress was relieved, the intracellular MDA content of Pueraria thomsonii Benth was still lower than that of Mikania micrantha, and Pueraria thomsonii Benth had more osmoregulatory substances, which indicated that the membrane lipid oxidation level of Pueraria thomsonii Benth was lower than that of Mikania micrantha. Under waterlogging conditions, the biomass of Pueraria thomsonii Benth increased, while that of Mikania micrantha decreased continuously. On the whole, Pueraria thomsonii Benth had stronger adaptability to water stress than Mikania micrantha, so we can use Pueraria thomsonii Benth to inhibit the spread of invasive plant Mikania micrantha by growth competition. An in-depth understanding of the invasive plants' growth characteristics can help us to understand their invasion response mechanism, and then solve the ecological problems which are caused by plant invasion.

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