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Study on the Lateral Root Branch Tensile Mechanical Characteristics of Three Kinds of Plants at Exuberant Growth Period

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Abstract. By means of the method of axial direction tensile test,applying three fixed fixture,this paper researches on the tensile mechanical characteristics of 3-4 a water and soil conservation plants:*Hippophae rhamnoides* Linn.,*Caragana microphylla* Lam.,*Artemisia sphaerocephala* Krasch. Lateral root branch in Ordos area Inner Mongolia Autonomous Region in China. The results showed that: In the stretching process, the lateral root branch in relative with the adjacent straight section root can easily be destroyed.The lateral root branch anti-tension of three kinds of plants had a trend of increasing with the root diameter increasing,the tensile strength had a trend of decreasing with the root diameter increasing.At the same root diameter,the lateral root branch anti-tension and tensile strength of three kinds of plants compared: *Caragana microphylla>Hippophae rhamnoides> Artemisia sphaerocephala.*

Keywords: Lateral root branch, Anti-tension,Tensile strength

1. Introduction

The root is the vegetative organ to contact with the soil directly,not only it can absorb the water and nutrient from the soil to meet plant growth and development,but also enhance the soil resistence to erode and shear.In recent years,the study of plant root system is increasingly becoming the focus of peoples' attention. At present,the mechanism study of plant roots strengthing soil has two types.One type focus on straight segment to study its tensile characteristics, root soil interface frictional characteristics and soil-root composite shear characteristics.Li Chengkai[1]studied four kinds of herb plants roots,Yuan Shujuan[2] studied two kinds of shrub plant roots, to conduct single root tensile test indoor.The results showed that:single root anti-tension increased with root diameter increasing; single root tensile strength decreased with root diameter increasing.Hu Xiasong[3] studied *Caragana korshinskii*,*Antiplex canescens*,*Zygophyllum xanthoxylon*,*Nitraria tangutorum*,Yao Xijun[4] studied *Sabina valgaris* Ant.,*Salix psammophila* C.Wang et Ch.Y.Yang,*Caragana microphylla* Lam.,*Artemisia sphaerocephala* Krasch.,Zhang Yongliang[5] studied *Hippophae rhamnoides* Linn.,to conduct root-soil composites direct shear test.The results showed that: When the soil physical and mechanical properties was in the same condition,the root-soil composite shear strength was greater than the prime soil.Zhang Chaobo[6] and Liu Xiuping[7] used triaxial compression test to study *Robiniapseudoacacia* root-soil composite.The results also showed that:the root-soil composite to resist shear ability was more than prime soil. Another type focus on the whole plant root to do situ pullout and shear tests. Li Shaocai[8] and Li Guorong[9] used situ pullout test outdoor to evaluate pullout resistance of plant samples,the results showed that : the ultimate anti-tension increased with the root diameter increasing.Ali,F.H.[10] used a modified large shear box apparatus(300mm×300mm) to cultivate *Vetiveriazizanoides*,*Leucaenaleucocephala*,*Bixaorellana* and *Bauhiniapurpruea* in the laboratory, the results showed that:roots significantly contribute to the increase in soil shear strength.Zhou Yunyan[11] conducted situ shear test using *Cinnamomum camphora*, the results showed that:the existence of the root improved the

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peak strength and residual strength of the soil;compared with prime soil sample,four containing root sample displaecement value was greater corresponding to the intensity of the peak point,before the soil shear brake, the containing root soil could withstand greater deformation, the root system increased the ductility of the soil.

Due to the randomness of root distribution,it is difficult to control single factor for whole plant roots' reserach. The common way is used straight section root to research root charateristics and evaluate the whole plant roots strengthing soil effect.But applying straight section root to evaluate the whole plant roots has always been a assumption. It is that the straight section root tensile mechanical properties is the same with the lateral root branch. If the tensile mechanical properties of lateral root branch is less than the straight section root,the lateral root branch will be broken firstly.The entire root system will become numerous single segment of root and can not constitute a interconnected network.Based on specific plants' biomechanical indicator,Endo and Tsurnta construct root biomechanic model. Wu proposed further experimental verification.This showed that the calculated valueswere often greater than the test measured values[12].Therefore,using the straight section root to evaluate root strengthing soil mechanical characteristics exists error, the lateral root branch characteristics must be taken into account.

By means of the method of axial direction tensile test,applying three fixed fixture,this paper researches on the tensile mechanical characteristics of 3-4 a water and soil conservation plants:*Hippophae rhamnoides* Linn.,*Caragana microphylla* Lam. and *Artemisia sphaerocephala* Krasch.lateral root branch in Ordos area Inner Mongolia Autonomous Region in China.

2. Material and Method

2.1. Material

In the territory of Jungar Banner, Ordos City, Inner Mongolia Autonomous Region,China, a good growth, uniform distribution of *Hippophae rhamnoides*,*Caragana microphylla*. and *Artemisia sphaerocephala* plot was selected. Each plant was randomly selected 20 trees as a sample, repeated three times to measure diameter, height, crown width, taking the mean of each indicator as a measurement of the composite indicator of the plant. In all sorts of places, selecting the 3-4 a plants were similar to the composite indicator as standard strains. The standard strains of roots used the whole plant sampling excavation method. After sampling ,the roots were placed in the wet sand similar to root growth environment.When we were back to the laboratory, we would pick and take good root sample in a sealed bag, labeled, placed on 4 ℃ icebox to keep the root fresh and completed the test as soon as possible. The sampling time was mid-August at exuberant growth period.

2.2. Method

Root of each plant was graded according to 0.5mm branch at the center, along the three root axis direction, respectively, taken 15mm as a test root to do tensile test. Each diameter class had 20 repeats. From the lateral branch, three straight section root was made a mark every 5mm, cross measured mark diameter with a vernier caliper, and averaged.The straight section root diameter was the two mark average diameter.The diameter of the lateral root branch was measured every 120 °, taken the average of three times as the diameter of the branch . During the test, the root that breaks away from the folder mouth was considered as the effective experiment root. Test root was fixed in the three fixed YG (B) 026H-250-type strength tester (range 0-2500N), which loading speed was 200mm/min, recorded the maximum anti-tension and fracture type. The tensile strength was the ratio between the anti-tension and the calculated cross-sectional area of the breaks. Calculation of the cross-sectional area, the diameter was the test root diameter before loading.

3. Results and Analysis

3.1. Statistics for the Test Root Fracture Type

Table 1 is statistics for the test root fracture type. Excluding fracture of the root folder mouth, the remaining root number is the effective number of test root. Seen from table 1, the number of *Hippophae rhamnoides* the lateral root branch at fracture accounts for 84.21% of the effective number of test root. The number of *Caragana microphylla* the lateral root branch at fracture accounts for 96.04% of the effective number of test root. The number of *Artemisia sphaerocephala* the lateral root branch at fracture accounts for 91.23% of the effective number of test root. In the stretching process, the lateral root branch in relative with the adjacent straight section can easily be destroyed.

Table 1: Statistics for the test root fracture type

Plant name	Root numbers	The number of fracture folder mouth	The number of fracture taproot	The number of fracture lateral root branch
Hippophae rhamnoides	100	62	6	32
Caragana microphylla	174	73	4	97
Artemisia sphaerocephala	100	41	7	52

3.2. The Tensile Mechanical Characteristics

ure 1 is the curved shape of the relationship between anti-tension and root diameter of the lateral root branch of three kinds of plants:*Hippophae rhamnoides*,*Caragana microphylla*and *Artemisia sphaerocephala*.Seen from the lateral root branch of the three plants,the anti-tension is along with the root diameter increasing to increase. The relationship between anti-tension and root diameter of the lateral root branch of *Hippophae rhamnoides*,*Caragana microphylla* and *Artemisia sphaerocephala* can be used power function $y=18.47x^{1.3407}$,$y=26.433x^{1.6403}$ and $y=10.186x^{1.2668}$ to fit ,and the multiple correlation coefficient are 0.7386,0.8743and 0.6617. When the root diameter is 1mm,the anti-tension of the lateral root branch of *Hippophae rhamnoides*, *Caragana microphylla* and *Artemisia sphaerocephala* is 18.47N,26.433N and 10.186N. The anti-tension of the lateral root branch at the same diameter,the three plants compare: *Caragana microphylla* > *Hippophae rhamnoides*> *Artemisia sphaerocephala*.

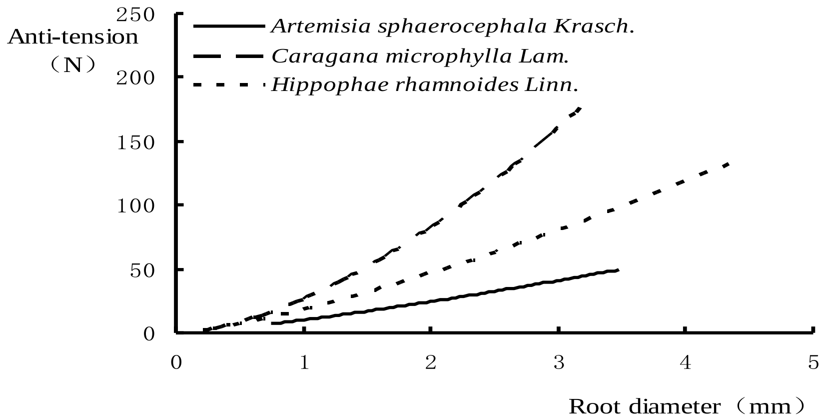


Fig.1: The relationship between anti-tension and root diameter of the lateral root branch of three plants

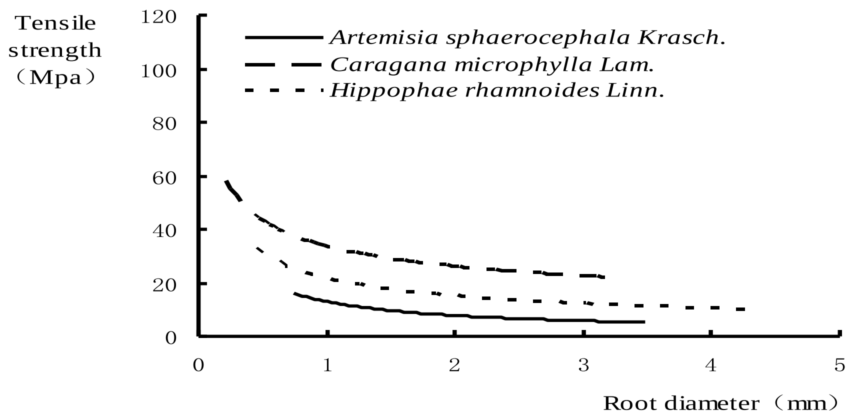
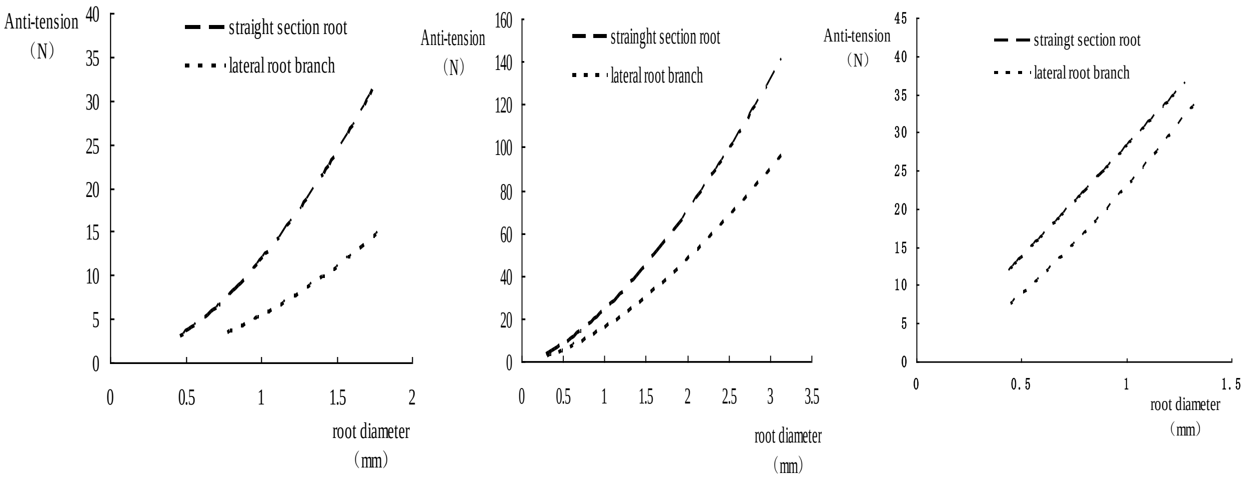


Fig.2: The relationship between tensile strength and root diameter of the lateral root branch of three plants

Figure 2 is the cured shape of the relationship between tensile strength and root diameter of the lateral root branch of three kinds of plants:*Hippophae rhamnoides*,*Caragana microphylla* and *Artemisia sphaerocephala*.Seen from the lateral root branch of the three plants, the tensile strength with root diameter increasing is a decreasing trend. The relationship between tensile strength and root diameter of the lateral root branch of *Hippophae rhamnoides*,*Caragana microphylla* and *Artemisia sphaerocephala* can be used the power function $y = 21.792x^{-0.5137}$, $y = 33.673x^{-0.3597}$ and $y = 12.975x^{-0.7332}$ to fit. When the root diameter is 1mm,the tensile strength of the lateral root branch of *Hippophae rhamnoides*, *Caragana microphylla* and *Artemisia sphaerocephala* is 21.792Mpa, 33.673Mpa and 12.975MPa. The tensile strength of the lateral root branch at the same diameter, the three plants compare: *Caragana microphylla*> *Hippophae rhamnoides*> *Artemisia sphaerocephala*.

4. Discussion

The tensile mechanical characteristics changing trend of three plants lateral root branch are basically the same with Yuan Shu-juan[13], Zhang Yong-liang[14]single root tensile mechanical characteristics of research findings. It is that the anti-tension with the root diameter increase tends to increase,the tensile strength has a decreasing trend with root diameter increasing. This shows that the plant roots, no matter straight section root or lateral root branch the tensile mechanical properties are essentially similar. But the ability to resist damage is far from each other. Figure 3 is the comparison of anti-tension between three plants straight section root and the lateral branch. In order to avoid the impact of the growth period and the site conditions, lateral root branch and straight section root took from the same plants.Seen from the figure,the straight section of three plants root anti-tension is greater than the lateral root branch. It also confirms that the ability to resist destruction of the straight section of the root is greater than the lateral branch.



Artemisia sphaerocephala *Caragana microphylla* *Hippophae rhamnoides*

Fig. 3 The comparison of anti-tension between three plants straight section root and lateral root branch

5. Conclusion

The statistical results of test root fracture type show that the number of *Hippophae rhamnoides*,*Caragana microphylla* and *Artemisia sphaerocephala* lateral root branch at fracture accounts for respectively 84.21%,96.04% and 91.23% of the effective number of test root .In the stretching process, the lateral root branch in relative with the adjacent straight section root can easily be destroyed.

The anti-tension of three kinds of plants the lateral root branch has a trend of increasing with the root diameter increasing,the tensile strength has a trend of decreasing with the root diameter increasing.At the same root diameter, three kinds of plants the lateral root branch compares：the anti-tension and tensile strength of *Caragana microphylla* > *Hippophae rhamnoides* > *Artemisia sphaerocephala*.

6. Acknowledgements

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