Tree Roots Tensile Strength concerning the forest slope stability in Nuevo Leon, Mexico.

○Laura Sanchez-Castillo (Graduate School of Bioresources and Bioenvironmental Sciences, Kyushu University)
Tetsuya Kubota (Faculty of Agriculture, Kyushu University)
Israel Cantu-Silva (Faculty of Forestry Sciences, UANL, Mexico)
Maria Ines Yañez-Díaz (Faculty of Forestry Sciences, UANL, Mexico)

1. INTRODUCTION

Vegetation affects the stability of slopes in significant ways. The stabilizing benefits of woody vegetation range from mechanical reinforcement and restraint by the roots and stems to modification of slope hydrology as a result of soil moisture extraction via evapotranspiration. Woody vegetation affect shallow mass stability mainly by increasing the shear strength of soil via root reinforcement, the value of the root system in this regard will depend on the strength, properties, and concentration of roots, branching characteristics and distribution inside the ground (Gray and Sotir, 1996). Roots provide a reinforcing effect in the soil through their tensile resistance and frictional or adhesion properties. It is indispensable to determine the tensile strength of roots in order to establish their effects on slope stability. The objective of this study is to analyze the characteristics of root strength of two native species of Nuevo Leon for the improvement of soil bioengineering techniques to prevent shallow landslide disasters in the area.

2. STUDY AREA

The study area is located in Chipinque National Park in Nuevo Leon state in the northeast part of Mexico (Fig. 1 (a)). Chipinque Park is a part of the Natural Protected Area Cumbres de Monterrey National Park, has an extension land of 1,815 ha, located in the municipalities of San Pedro Garza Garcia and Monterrey in the Sierra Madre Oriental Mountain Range, presents altitudes ranging from 750 to 2,200 m.a.s.l.. The dominant soil types are litosol and rendzin. The average annual rainfall between 1970 and 2009 was of 852 mm (Fig. 1 (b)). The general vegetation in the study area consists of mixed forest composed of species of *Pinus* and *Quercus*. *Pinus* species among which are *Pinus pseudostrobus* and *Pinus teocote*, and Quercus species like *Quercus rysophylla* and *Quercus laeta*.

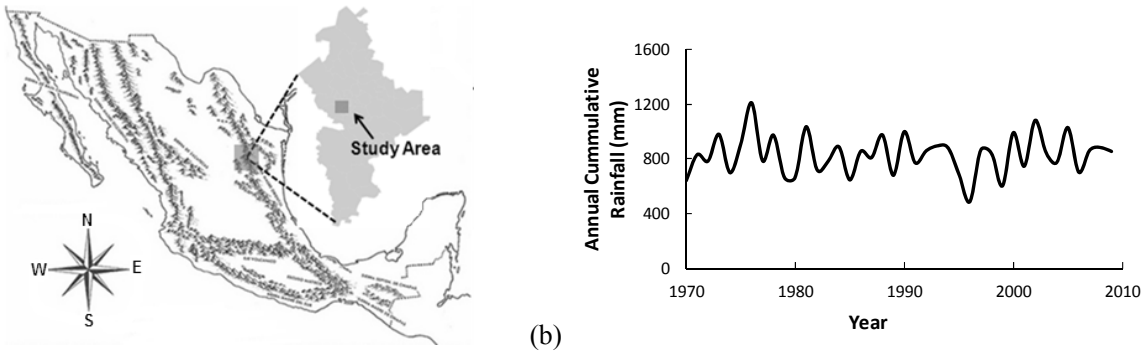

Fig. 1: (a) Location of the study area. (b) Annual cumulative rainfall in Nuevo Leon, Mexico

3. METHODOLOGY

For the determination of root tensile strength a Universal Testing Machine Shimadzu type SLFL-100KN with a data processing and recording unit was used. The tree root samples were tested under strain-controlled conditions. Root samples of 100 mm with different diameters were taken from sections of the roots of mature trees of the species: *Pinus pseudostrobus* and *Quercus rysophylla*. Roots samples in which failure didn't occur in the middle part of the sample were discarded as many tensile test failed due to slipping, poor end gripping or influenced by the clamping device. With the test conducted on laboratory we could obtain values of Maximum Force to failure (MaxForce), Tensile Strength and Modulus of elasticity (MOE).

4. RESULTS & DISCUSSION

Successfully tensile strength test were conducted in 54 root samples of specie *Quercus rysophylla* and in 52 root samples of *Pinus pseudostrobus*. From the tests of *Quercus rysophylla* root samples we could obtain average values of maximum force needed to failure of 178.7 N, average tensile strength of 87.64 N/mm^2 and MOE of 161.8 N/mm^2. While *Pinus pseudostrobus* shown average values of 204.2 N, 71.29 N/mm^2 and 80.27 N/mm^2. Relationships between Root diameter and MaxForce, Tensile Strength and MOE are shown on Fig. 2. In all species analyzed on this study the maximum force needed to failure increases as the root diameter augment, opposite to the relationships of Tensile strength and MOE that decreases as the root diameter of samples increases. Moisture content on the root samples showed an average percentage of 21.45% in *Quercus rysophylla* and 43.33% in *Pinus pseudostrobus*.

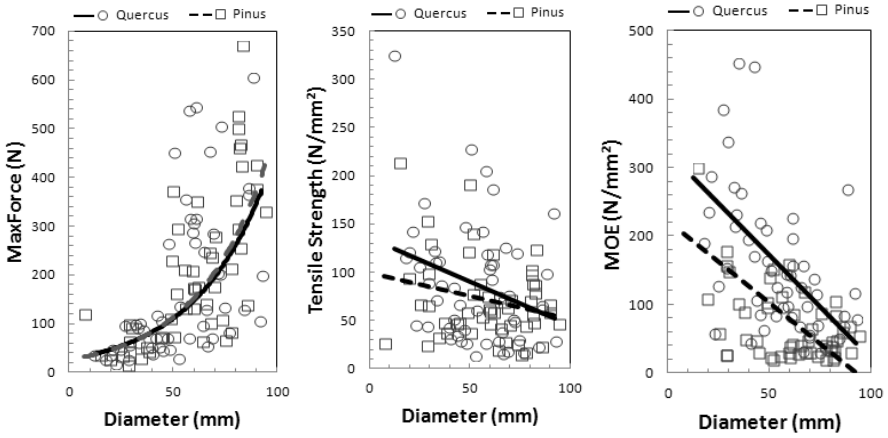

Fig. 2: Relationships between root diameter and maximum force to failure, tensile strength and modulus of elasticity.

5. CONCLUSIONS

From data obtained in this study we could observe that species *Pinus pseudostrobus* gave the highest values of root strength compared the ones given by *Quercus rysophylla* , being a native species, could be effective in stabilizing slopes of Nuevo Leon. The effect of tree roots on the slope stability can be measured in terms of their strength, and their distribution within the soil strength values were provided in the present study. Although root soil complex is a dynamic system in where a great number of factors interact, the obtained results can be useful in slope stability analysis for the improvement of soil bioengineering techniques to prevent shallow landslides and erosion problems in forest slopes of Nuevo Leon, Mexico.