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A study on the resistance of roots of plant species used in stabilizing Helmand river banks

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Abstract

One way to stabilize the river banks of Sistan bioengineering are using. Penetration of plant roots in the soil on the slope of the soil as soil reinforcement in concrete may be armed. This increases the soil shear strength and slope stability soil. In recognition of this process and the use of appropriate species, the environment and resistant roots, dirt slope stabilization projects will be done in a scientific way. In this study, field survey was conducted to identify the native plants of the region. In this context, the dominant native plant species identified, the Tamarix,tamarix aphylla, willow, Euphrates poplar, eucalyptus and reed is. The examples of roots grown in the riverine plant species were collected. And then the samples under standard conditions that natural moisture was retained, transferred to the laboratory and the tensile strength of the roots examined and tested. Then the measurement data with the rest of the evaluated. According to the results indicated that Eucalyptus trees and tamarisk trees in the river of higher tensile strength than any other region and are due to the beneficial effects of native plants, it is recommended to arming and sustainability Sistan River used.

Keywords: bioengineering, shear strength, tensile strength, stability beaches, river Sistan

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1. Introduction

Rivers, as one of the natural resource beds embodies elements which are put together in dynamic balance and any change in one of the elements triggers domino effect to cause change in other elements too. Stable and long lasting exploitation of river sources requires utilization of methods compatible with river environment. Presently, human society is more dependent on the rivers than before and in case of flooding or overflowing of the rivers or erosion of riversides, plenty of economic sources will be in jeopardy. Therefore human being has incessantly been after methods to stop flooding or overflowing or at least reduce the level of loss it incurs. the main reasons to count on the erosion of river banks are as follows: washing off soil particles due to waves and currents, washing off river bank slopes and inner bank failure, increasing riverbank slope due to the erosion and leaching, increasing pore water pressure when fully saturated, inner slope failure due to water leakage toward the river, laundry and many other factors involved.

Building up vegetation on Sistan riverside affects positively both on the stability of slope surface and on the stability of roof body in many ways. These effects are applied through hydro mechanical ways such as armed soil to soil hydrological modification by roots, plant leaves prevention of direct rain drops falling onto slope soil , absorbing soil moisture by roots through the processes of evaporation or sweating, etc. Thick vegetation such as meadow plants or bushy plants is one of the best methods of protection against surface erosion because of water or wind. Destroying vegetation causes a great deal of erosion and frequent repetition causes slope slip and failure.

The most positive effect plant trees can have on soil is by making soil armed through roots. Sometimes legging out and pillar imprint are significant if only the underneath bed is strong enough. sweating, evaporation and pore pressure reduction play an important role in slope`s balance. The most negative plant tree factor in mass stability is overloading originating from their weight in case that wind or water force them upward to uproot them. One good solution here to eradicate negative factors is grafting. it helps keep big and strong roots, instead of heavy and big trees , and makes room for short and multi branch trees. For bio engineering performance, some varieties look more suitable than others. By variety, we mean general forms and features and in practice, we need to find similar local varieties. favorite features and characteristics of vegetation are as follows: soil-arming , absorbing water from soil , protection of slope surface or soil against human and domesticated animals trafficking , protection of soil surface or slope surface against destructive forces such as wind , water (water current or waves motion in general) and slopes stability . Soil alone is not highly resistant, esp. tensile resistance which is overlooked in calculations. However, if the mentioned soil is armed, then its resistance will highly increase .the tensile resistance of roots of some trees are about 700 kg. Per square meter which is about one fifth of tensile resistance of fittings. Plant trees have stronger roots and therefore, mechanically speaking have a better performance. Their strength regarding soil arming and legging out or linking the lower layer to the upper layer grows bigger. On the other hand, meadow and bushy plants grow closer to each other and occupy more of soil surface. Hence, soil is overlooking less water erosion. so focus must be on the main performance expected from vegetation and choose the suitable variety. in line with this study, various sources have been compiled among which are the following : Valdron (1977) , Valdron and Daksian (1982) ,Gary & Ohashi(1983), Barker(1986) , woo et al(1988) , Sh . Bedridge & sittar(1981,1990,1996) , A. &Zaymer(1991) , pointed out on soil arming models. also, Valdron(1977,1981), Gary & Ohashi (1983) , woo et al(1983,1983), woo & Watson (1998) carried out a study on laboratory cutting test. on the above-said research, we may refer to Zaymer(1981), woo et al (1988) , Woo & Watson's research (1998) . on the geometry of roots valdron and Daksian (1981), Zaymer(1981), Gary & Mc.Donald(1986) , Woo et al(1988) and H.chavnich(1999) have done studies. on roots tensile resistance we may refer to the researches done by valdron (1981), G.S (1996) and H. chavnich (1996). Studies and experiences of different researchers shows that natural slopes and river bank which are covered by trees and bushes, are more stable than slopes without any vegetation. Many case studies have been reported in sources. if trees and plants are cut down , then slopes and river banks slide and cause a large scale and extensive destructions. in this research we have studied local sample roots resistance

2. Materials and Methods

First off, to reach the goals of this study, some surveys were carried out in the area and intervals of Sistan river regarding vegetation based on the said carried out- survey was done . accordingly Sistan river was divided into 5 intervals.

Intervals	Length (km)	Vegetation cover
I: Area from Helmand 3-branch to Kohak dam	2	No cover
Π: Area from Kohak dam to Sistan dam	14	Relatively devoid of vegetation
III: Area from Zahak dam to Sistan dam	5	Relatively devoid of vegetation
	14	With vegetation
IV: Area from Sistan dam to 3 branch Adimi & Afzalabad	12	vegetated flood –blocking
V: Area Adimi three branches and Afzalabad	12	Almost without vegetation

Table1: Zoning Sistan River vegetation

intervals numbers 3 and 4 from Sistan which were about 14 and 12 kilometers in length were chosen since they were suitably vegetated . Considering the studies and surveys done along Sistan river, trees such as Tamaricacea,Tamarix,popolus euphratica,Salix Spp, Phragmitas australis and eucalyptus which were among the prominent and dominant trees of the region were selected to be studied on. To determine a numbe of primary features of mechanical behavior of roots such as max. Tensile resistance, elastic limit force, max. power failure, proportional stress limit, final stress and elasticity module, we need to carry out some tensile resistance experiment. to determine tensile resistance of the roots , we needed to collect some samples of eucalyptus , populous euphratica,river Tamarix ,Tamaricacea ,Phragmitas australis and Salix Spp. Samples were collected from different regions and conditions and with different diameters. all samples were excavated then . to prevent roots from withering , they were put in plastic bags and taken to a laboratory for testing. the force measurement precision is up to 0.001N and the movement is 0.001mm .

the samples which were 15 cm long were selected for the experiment and put between clamping jaws. the experiment was carried out on the peeled-off samples since the ones with barks could slip off the jaws. the samples diameter was measured by caliper before and after peeling off on two perpendicular sides. next, samples are placed between the clamping jaws to pull them by a speed of 5mm per minute. fig. 1 shows how to place the samples between the jaws. one of the points to consider while doing the experiment is having no stress concentration in the jaws . since it may damage the samples at one end. they(samples) may also lose some water and slip off the jaws. to prevent such occurrence a piece of rubber would do the job.. generally speaking , 144 tests were carried out on different samples of eucalyptus, popolus euphratica,river Tamarix, Salix Spp,Phragmitas australis.due to the limitations of the articles pages , we only discuss about few samples here. for instance, fig. 2 shows the tensile resistance curve against moving .

Row	Diameter (mm)	The elastic force (KN)	Maximum force (Kn)	Maximum tensile strength (mpa)	Modulus of elasticity (mpa)	Proportional stress σ_{pl} (mpa)
1	2.61	0.075	0.4765	89.1	1	12.93
2	6.65	0.438	1.241	26.38	785	6.45
3	9.83	0.525	1.424	16:58	446.6	1.118
3	9.93	0.401	1.111	13:48	462.9	1.001
4	9.18	0.56	1.52	22.97	474	4.195
5	2.87	0.157	0.4335	65.5	1405	4.649
6	6.97	0.4	1.11	29.09	987	2.427
7	5.03	0.239	0.643	32.35	673	2.143
8	4.6	0.308	0.846	50.9	727	18.53
9	3.61	0.2415	0.672	65.7	1155	23.53
10	10	0.803	2.193	27.92	776	1.994
11	3.35	0.375	1.034	64.7	2812	24.42
12	5.33	0.4313	1.196	53.6	956	19.3
13	4.64	0.312	0.855	50.6	645	18.45
14	3.25	0.2565	0.685	82.5	909	30.92
15	1.89	0.0625	0.1633	57	4576	7.74

Table 2 also shows tensile resistance for 15 types of Tamarix .

Fig.1 shows method of placing samples in the device .

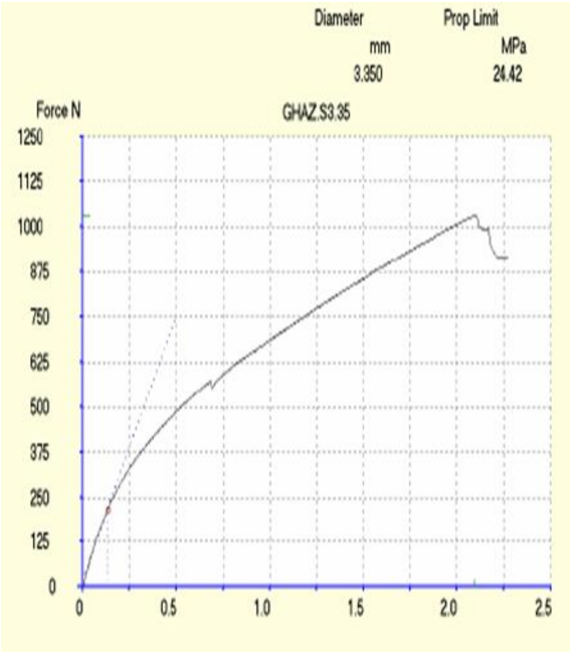


Fig. 2 shows curve displacement against the force of testing the tensile strength of tamarisk tree root

Fig.2 prepared sample roots for experiment.

Processing data obtained from plant's roots tensile resistance tests

Regarding the presented materials in the past sections, some of the features of roots are effective in estimating the behavior of soil and roots together. in reactions of soil and root, tensile stresses on roots changes to shear resistance in soil and reinforces and stabilizes slopes. one of the salient tests to learn more about mechanical characteristics of roots are tensile resistance tests . due to the limitation of the pages of this study , the data earned from tensile resistance tests have been presented in table 2 . in the second column of the table , root diameter is in millimeter , in the 3rd column, force in elastic limit is in kilo Newton . in 4th column , force is in failure limit . in the 5th column max. tensile resistance which is obtained from division of force in failure limit on root cross section. columns 6,7,8 respectively are elasticity module, final tension and proportional tension limit in Mega Pascal. to do a survey on the possibility of establishing a relationship between any one of the above said parameters and root diameter, figures 4&5 respectively , show maximum roots tensile strength and roots tensile resistance against diameter for some trees such as eucalyptus, Pupolus euphratica ,Tamarix, Salix Spp, Phragmitas australis . As it is seen, when the root diameter grows larger , the level of strength in failure limit is increased and roots tensile resistance is reduced. fig. 7 also proves that in comparison with these plants, eucalyptus,Tamarix,Salix Spp,popolus euphratica and Phragmitas australis roots are capable of tolerating more strength to the breaking failure respectively.

Using equations (1) to (11), we may determine the level of maximum strength in failure limit and maximum tensile resistance knowing the diameter. The drawn lines were obtained through laboratory processed data. Out of the quantities earned and by having roots diameter , maximum strength in failure limit and then increasing soil shear resistance in cylindrical model is used.

Based on the results obtained from excel program, correlation coefficient among these parameters is less than 0.5 in diameter. The only relatively acceptable relation derived out of these data is as follows: 1- maximum tensile resistance with diameter relation . 2- relation between maximum strength in failure limit with diameter. the noteworthy point here is that these equations were defined in a intervals of (0-15 mm).

these equations are :

1-maximum tensile resistance with diameter equation:

for eucalyptus tree : (1) $$S = -55.617\ln(D) + 130.32$$

for Pupolus euphratica tree : (2) $$S = -21.666\ln(D) + 136.45$$

for Tamarisk tree : (3) $$S = -49.636\ln(D) + 128.28$$

for Salix Spp tree : (4) $$S = -40.536\ln(D) + 99.023$$

for Reed plant: (5) $$S = -16.261\ln(D) + 39.836$$

equations between maximum strength in failure limit with diameter

for eucalyptus tree : (6) $$F = 0.0213D^{2.1639}$$

for Pupolus euphratica tree : (7) $$F = 0.06D^{1.24}$$

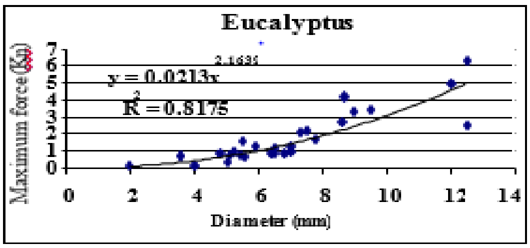
for Tamarisk tree : (8) $$F = 0.1414D^{1.1448}$$

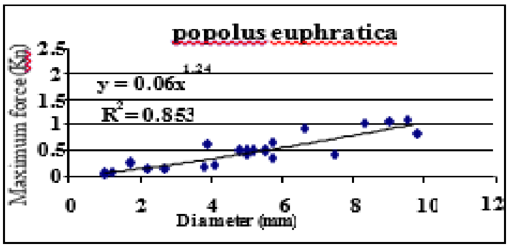
for Salix Spp tree : (9) $$F = 0.0306D^{1.7846}$$

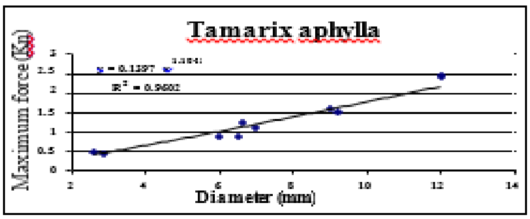
for Reed plant: (10) $$F = 0.0304D^{1.3454}$$

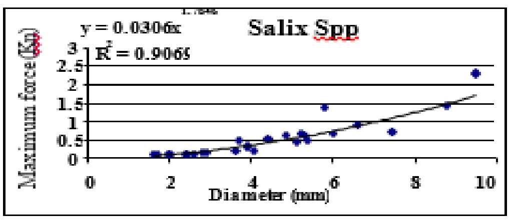
For all samples: (11) $$F = 0.0613D^{1.3657}$$

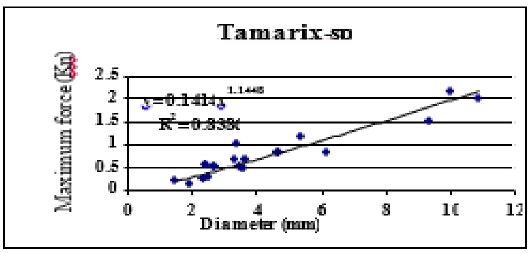
in the above relations F is maximum force in failure limit calculated in KN and D is root diameter in mm.











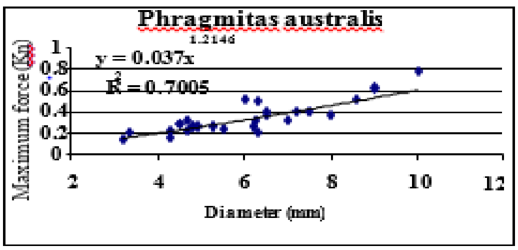


Figure 4: maximum power at the failure against diameter for Eucalyptus, popolus euphratica,Tamarix,Salix Spp, Phragmitas australis

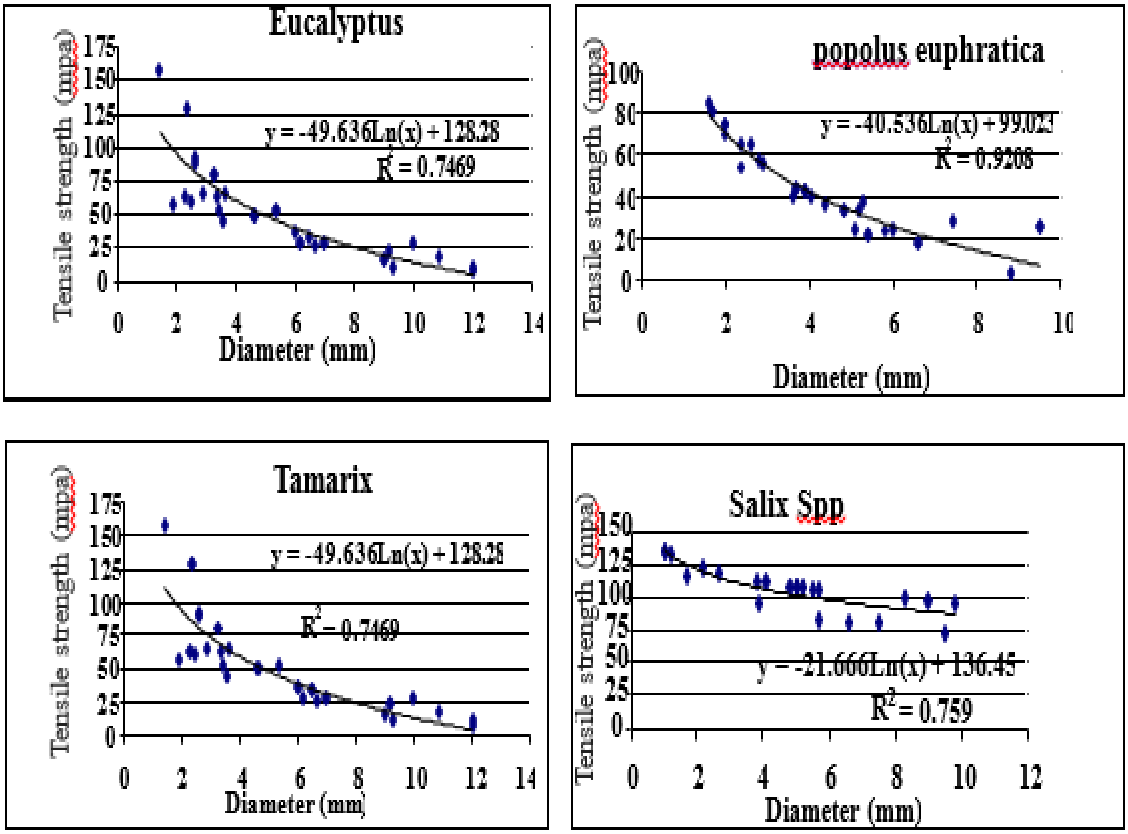


fig.5 : maximum tensile resistance against diameter for Eucalyptus, popolus euphratica,Tamarix,Salix Spp, Phragmitas australis

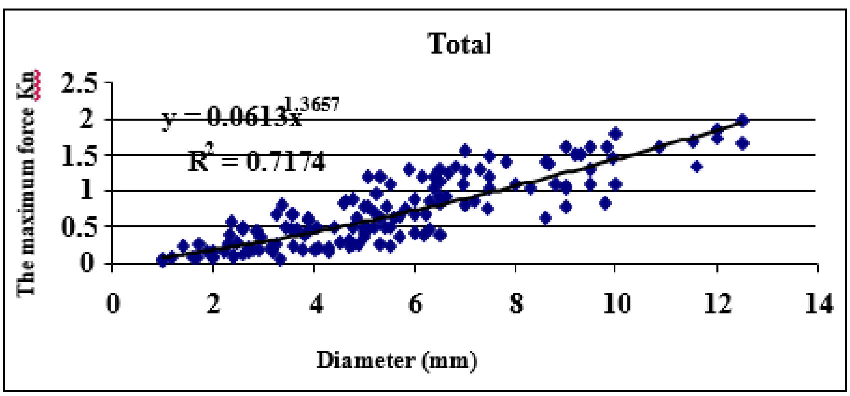


Figure 6: The relationship of forces in the failure of diameter for trees

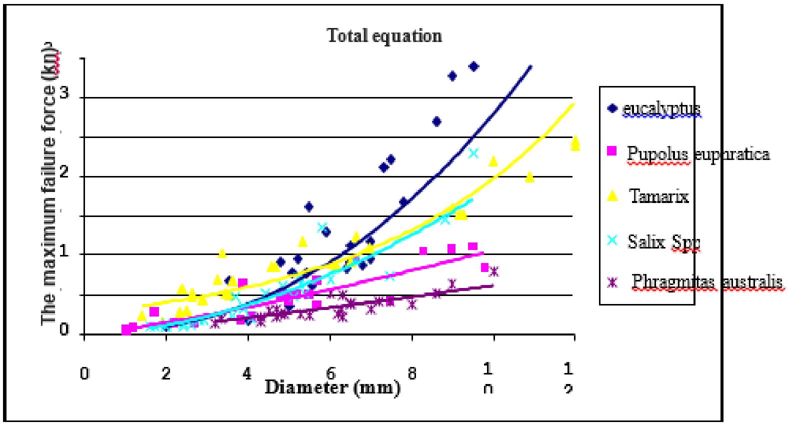


Figure 7: Comparison of the rupture force versus diameter eucalyptus, Pupolus euphratica ,Tamarix, Salix Spp, Phragmitas australis

eucalyptus, Pupolus euphratica ,Tamarix, Salix Spp, Phragmitas australis

Calculation of increasing soil shear resistance using roots tensile resistance data

to calculate the level of increasing soil shear resistance at any depth it is possible at first to determine the roots diameter in that depth using the geometry model. Calculations here were carried out on the results of Tamarix and Popolus euphratica trees which are both among old trees so that we can compare the results of both trees.. therefore , using the computer program outcome results , spot roots that have passed a certain depth such as z, then using the interpolation method , calculate the root diameter (D) in that depth (Z) .

in which D1,D2 root diameter at both ends and Z1,Z2 is both sides depth .

$$D = D_2 - \frac{(D_2 - D_1)(Z - Z_2)}{(Z_1 - Z_2)} \quad (12)$$

Depth (cm)	increasing Soil shear strength (kp)	
	Tamarisk	popolus euphratica
20	0.93	0.301
40	1.66	0.50
60	2.803	0.72
80	4.50	1.35

100	6.898	1.50
120	10.72	2.15
140	14.464	3.80
160	5.235	6.23
180	0.357	5.11
200	0.0035	3.079
220	-	17.75
240	-	8
260	-	0.3

Table(3) : increasing soil shear resistance (in in kPa) relative to the depth for Tamarix and popolus euphratica.

in the next phase, cylindrical model plan, calculates F quantity for any root considering its type through equations (1) to (11). F quantity is equal to the product of maximum root tensile in root cross section i.e TA . therefore , if F quantity for all perpendicular roots are calculated and added to each other, in fact $\sum_{i=1}^{n} A_I T_I$ quantity is calculated. Hence, if the calculated final result is divided by cross section and multiplied by 1.15, then AS quantity or increasing soil shear resistance at that depth regarding equation (12) $= 1.15 \frac{\sum_{i=1}^{n} A_I T_I}{A}$ is obtained. the results of this section has been presented in table 3. as you can see , Tamarix tree has added to the soil shear resistance in 140cm depth perpendicular to the river bank up to 14.46 KP and popolus euphratica tree has increased the soil shear resistance down to the 2.6 meter depth perpendicular to the river bank and has had the most impression down to 2.2 meter depth up to 17.75 Kilo Pascal.

P.8 therefore while using the vegetation for stabilizing river banks, root characteristics and conditions must be taken into consideration. Results show that river Tamarix tree due to the higher root density and more root branches and more compatibility with the environment for soil arming in lower depths and a shorter period of time seems more suitable. For a longer period of time also it is possible to plant popolus euphratica tree to help soil arming for lower depths. it must be noted that to a certain depth, trees could help increase soil shear resistance. Hence, it is usually recommended for river bank heel stabilization implement structural method and for upper layers use vegetation method. Also regarding the helpful effects of V. and A. it is suggested that these plants are used in some projects esp. for neutralizing waves effect on river banks. it is also possible to establish a special research center like other countries.

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