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# An examination of the use of "vetiver grass" to prevent erosion in Yusufeli Region (Çoruh Watershed area-Turkey): A case study

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***Abstract :*** *The goal of this study is to explore opportunities for plantation at Çoruh Watershed area, where severe erosion has been observed, using "Vetiver grass" which has proven successful in preventing erosion in South America and in other countries.*

*A site on the banks of the Çakaloğlu stream located in the borders Yusufeli settlement is chosen as a study area and four experimental sites were been determined considering altitude (700-750 m., 750-800 m.), direction faced by the sites; facing South and facing North-East and slope (%53, %60). At these experimental sites, eight parcels have been formed, one being control and the rest being experimental. Soil patterns taken from two different depth levels; 0-30 cm. and 30-60 cm. and Vetiver grass being tested at these parcels have been used as material.*

*The lengths of stem and root and vegetation coverage of the plants at the sample parcels have been measured and the shoot numbers have been counted. Analysis for soil patterns, soil texture, pH, dispersion ratio and erosion have been done on specimens of soil taken from the sample sites. Using the obtained data, observations and the results of tha analysis of variance (ANOVA), it has been concluded that "Vetiver grass" can be used at the steep slopes of arid regions where erosion is severe to prevent erosion due to the fact that it has proven successful in holding the soil.*

***Key words :*** *Vetiver grass, Ground cover plant, Erosion, Stabilization, Yusufeli.*

## Introduction

Turkey is one of the countries where erosion happens in various ways and at various strengths. The current study was carried out at Çoruh Watershed area, one of the sites where water erosion happens at its strongest. At this watershed area 43 % of land has been subjected to strong erosion and 18 % of land has been subjected to erosion at medium strength (Demirel *et al.* 2002). 95 % of land at the area consists of shallow soil which presents a successful tree plantation against erosion. The reason for this is that the trees planted in shallow soil can not use enough water and nutritious water leading to an insufficient growth at the roots which can not prevent erosion. Thus it would be a better approach to use ground cover plants, which have a high potential to provide slope stabilization and to hold on to the soil, at places where the soil is shallow.

Some examples of practical erosion prevention and slope stabilization study using ground cover plants and some methodological studies that were done in Turkey are; Koç (1977), Çelem (1981), Korkut (1987), Acar (1998), Akdoğan (1972), Koç *et al.* (1987), Öztan and Arslan (1992), Arslan *et al.* (1996), Çelem (1988), Altan (1982), Güçlü *et.al.* (1998), Perçin and Arslan (1995). There is not any application studies using "*Vetiver grass*" in Turkey, however some examples can be given from other countries such as; The World Bank (1990), National Research Council (1993), Grimshaw and Helfer (1995), The Vetiver Network (1996, 1997), Bevan and Truong (2000), Truong (2000), Wang *et al.* (1999).

"*Vetiver grass*" plant, which has shown very successful results in the prevention of erosion especially at places where erosion is very strong, was tried for the first time with this study at Çoruh Watershed area providing observations about the adaptation of the plant to the area.

## Materials and Methods

The study area is in the Eastern Blacksea Region, Yusufeli Town, 85 km. southwest of Artvin City, 500 mt. from the town center. Çakaloğlu creek and surroundings where the experiment site is located is the plantation area of Yusufeli Forest Management and it is steep (Fig. 1).

4 experiment sites were used at two different altitudes (700-750 m., 750-800 m.) and two different aspects (North-East and South). "Vetiver grass", which was planted as a ground cover plant in these four

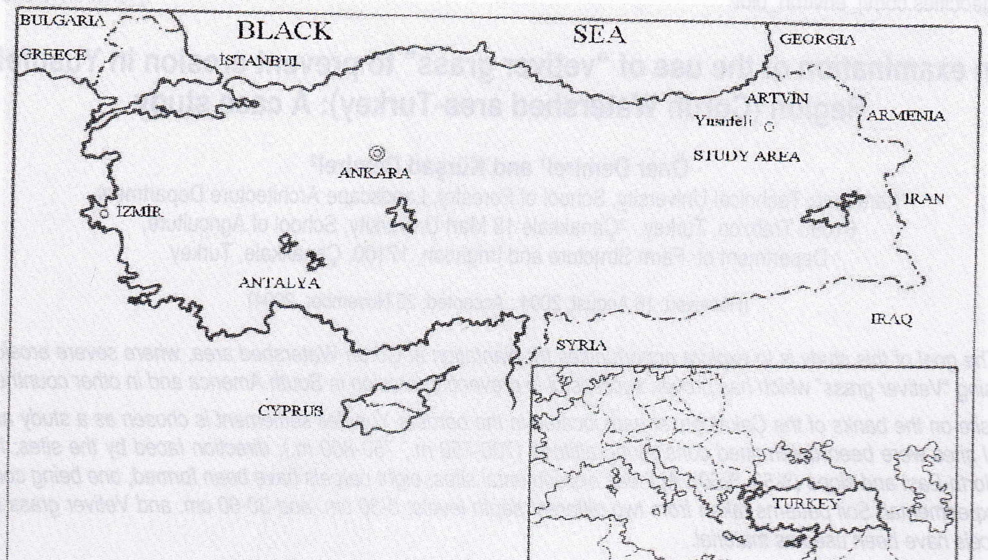



**Fig. 1 :** Geographical location of the study area.

**Fig. 2 :** Vetiver grass.

experiment sites was brought from Nepal and was used for the first time in the region (Fig. 2). Vetiver plant, used for prevention of erosion especially at inclined areas and slopes has as its natural habitat swamps and humid regions located at low altitudes. Although it is native to wetlands (North India), its resistance to drought and its high potential for holding soil has made its use very widespread (Table 1).

In Yusufeli region, the proportion of erosion at low-medium and high strengths is 93 % (T.C. Köyişleri ve Kooperatifler Bakanlığı., 1981). Considering the natural plant geography of the region which is quite distinct in that at the banks of Coruh (565 m. altitude) Mediterranean plant forms (pseudomaki) are dominant, (Demirel, 1997) the probability of adapting an exotic plant to the region was seen strong and the decision was taken towards trying "Vetiver grass" ,which is non-native to the area, in order to prevent erosion.

Eight soil samples taken from each experiment parcel at two different depths levels (0-30 cm, 30-60 cm.) were used as material. In addition, an altimeter was used to measure altitude, Bazard compass was used to determine exposition and lengths of plant stems, crowns and roots were measured at metric scale.

While choosing the experiment parcels an important consideration was not to choose parcels from an altitude lower than 710 meters because the soil under this altitude will get submerged after the construction of Yusufeli Hydroelectric Power Plant. It was, therefore, guarantied that the plants will not get submerged after the water level goes up to 710 meters. The Project for a

**Table – 1 :** A number of singular anatomical features of "Vetiver grass" for purposes of erosion control, (National Research Council., 1993; The World Bank., 1990; Hengchaovanich and Nilaweera, 1996; Hengchaovanich, 1999; Truong *et al.*, 1995; Truong, 1999).

| Anatomical features | Importance from point view of erosion control |
|---|---|
| Habit | The plant has an erect habit and keeps its leaves up off the ground. This seems to be important in allowing the hedge to close up tight. |
| Resistance to toppling | Unlike many grasses, *Vetiver* is "bottom heavy". It shows no tendency to fall over, despite its very tall culms. |
| Strength | The woody and interfolded structures of the stems and leaf bases are extremely strong |
| Year-round performance | Although *Vetiver* goes dormant during winter months or dry seasons, its stems and leaves stay stiff and firmly attached to the crown. This means that the plant continues stopping soil, even in the off-season or after death. |
| Self-rising ability | As silt builds up behind a *Vetiver* plant, the crown rises to match the new level of the soil surface. The hedge is thus a living barrier that cannot be smothered by slow rise of sediment. |
| Underground networking | *Vetiver* is a sod-farming grass. Its clumps grow out, and when they intersect with neighboring ones they intertwine and form a sod. It is this that makes the hedges so tight and compact that they can block the movement of soil. |
| Clump integrity | For all practical purposes, *Vetiver* has no running rhizomes or stolons. This, too, helps keep the hedge dense and tight. |
| Leaves and stems | It is, of course, the leaves and stems that are crucial in this living-hedge form of erosion control. The leaves apparently have fewer stomata that one would expect, which perhaps helps account for the plant withstanding drought so well. It is the stems that provide the "backbone" of the erosion-control barrier. Strong, hard, and lignified (as in bamboo), they act like a wooden palisade across the hill slope. |
| Roots | Perhaps most basic to this plant's erosion-fighting ability is its huge spongy mass of roots (Fig. 3). These are not only numerous, strong, and fibrous, they tap into soil moisture far below the reach of most crops. They have been measured at depths below 3 m and can keep the plant alive long after most surrounding vegetation has succumbed to drought. The massive, deep "ground anchor" also means that even heavy downpours cannot undermine the plant or wash it out. Moreover, because the roots angle steeply downwards. |

**Fig. 3 :** The Roots of Vetiver Grass.

Hydroelectric Power Plant has been approved by the General Directory of Water Management and the construction will begin in couple of years. Thus all the parcels were chosen from an altitude above the damming level (700-750 mt, 750-800 mt.). A total of 8 parcels were chosen including a control parcel planned next to each of four experiment parcels in order to observe the tendency of the area towards erosion. (In each experiment area, there is a experiment parcel "4m. x 8m.:32 $m^{2}$" and a control parcel "4m.x 8m.:32$m^{2}$") (Fig. 4) (Table 2).

100 plants were planted in the parcels in April 2000. Four soil samples were taken from the area at two different depths (0-30 cm) and (30-60 cm). This was seen necessary in order to observe the roots of the plants at different periods, considering that the roots would reach a particular length in each of the four months the observations were done.

Crown-width and crown-length measurements at the experiment parcels were made using metric scale on

**Table – 2 :** The size of the experiment sites and physiographic qualities of their locations.

| Altitude grade | Altitude level (m) | Experiment parcels | Exposition | Location | Parcel ($m^2$) |
|---|---|---|---|---|---|
| | | 1 | South | Çakaloğlu | 64 |
| 1 | 700-750 | 2 | South | Çakaloğlu | 64 |
| | | 3 | North-East | Çakaloğlu | 64 |
| 2 | 750-800 | 4 | North-East | Çakaloğlu | 64 |

the reflection of all stem and leaf parts of the plants on soil. In order to observe root development of the plants at the beginning of every month measurements were made on the plants by removing from soil on 5x5 cm (sliced square-shaped unit). For the observation of length, at the 1st of each month, measurements were made on the plants.

The soil samples were analyzed for texture, pH, dispersion level and erosion level at Karadeniz Technical University, School of Forestry Soil Lab. (Table 3). Other parameters were not considered because the major objective of this study is to measure the capacity of the soil for preventing erosion. The soil samples were prepared for the analyses by drying and sifting through a 2 mm sieve. The texture analysis of the soil samples was done using the hydrometer method by Bouyoucos. For this analysis, 50 gr. samples were taken from heavy textured soil and 100 gr. samples were taken from sandy soil (Bouyoucos, 1936).

Middleton's method for finding proportion of dispersion was used to determine the dispersion of the soil samples. According to this method, the proportion of dispersion is calculated by dividing the amount of sandy soil and clay soil in a water-soil solution with the existing amount of sandy soil and clay soil in the soil from the area (Gülçür, 1974).

The tendency of the soil samples for erosion was determined using the proportion of dispersion in addition to slope (60% and 53%) and aspect (South and North-east). If the proportion is >15 the soil is not resistant against erosion if it is <15 it is resistant to erosion (Okatan, 1987). The pH level of the soil samples were measured on 1/25 mixture of pure water and soil using Orion 420 A digital pHmeter (Gülçür, 1974).

Data relating the development of the plants in the area (length, root length, number of shoots, crown sizes) was tested in order to find if there are differences between the plants depending on specific parcels and period by using analysis of variance (Ercan, 1995) (Table 4). Duncan's multiple test was used in order to find out the magnitude of the difference and the group that the parcels and different periods belong was determined. SPSS for Windows 7.5 program was used for the data analysis. The raw data was used in the statistical analysis without any transformation.

## Results and Discussion

**Comparison of experiment sites :** As a result of measurements and observations done in four different

**Table – 3 :** Analysis results of the soil samples taken from the experiment sites.

| | | Physical analysis | | | | Chemical analysis | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Experiment site | Depth (cm) | Sand % | Clay % | Dust % | Soil type | pH 1:2,5 | ECx103 25⁰C'de Milimens/cm | Organic material % | $CaCO_3$ Total | Proportion of Dispersiyon | Sensitivity of the soil against erosion |
| 1 | 0-30 | 85.39 | 8.46 | 6.16 | Clayed Sand | 7.6 | 0.13 | 0.85 | 8.36 | 29.24 | not resistant |
| | 30-60 | 85.37 | 6.41 | 8.22 | Clayed Sand | 7.78 | 0.16 | 0.82 | 4.17 | 29.26 | not resistant |
| 2 | 0-30 | 91.59 | 6.37 | 2.04 | Clayed Sand | 7.8 | 0.18 | 0.70 | 5.88 | 16.82 | not resistant |
| | 30-60 | 89.55 | 6.37 | 4.08 | Clayed Sand | 8.01 | 0.17 | 2.64 | 6.30 | 20.09 | not resistant |
| 3 | 0-30 | 81.34 | 10.48 | 8.19 | Sandy Clay | 7.91 | 0.13 | 1.32 | 5.63 | 37.34 | not resistant |
| | 30-60 | 77.89 | 13.37 | 8.74 | Sandy Clay | 8.06 | 0.13 | 0.85 | 5.50 | 44.22 | not resistant |
| 4 | 0-30 | 75.48 | 13.49 | 11.02 | Sandy Clay | 7.97 | 0.16 | 4.84 | 5.06 | 49.02 | not resistant |
| | 30-60 | 78.73 | 10.76 | 10.51 | Sandy Clay | 8.08 | 0.13 | 1.73 | 6.53 | 42.54 | not resistant |

**Table – 4 :** The analysis of values obtained from observations at the experimental sites using Anova.

| Development of plants | Experiment site | Number of samples | Mean | Standard deviation | *F*-value | *P*-value | Duncan test |
|---|---|---|---|---|---|---|---|
| LENGTH (cm) | 1 | 96 | 56,64 | 18,47 | 0,509 | 0,676 | *a* |
| | 2 | 96 | 54,88 | 15,10 | | | *a* |
| | 3 | 96 | 53,82 | 15,73 | | | *a* |
| | 4 | 96 | 56,05 | 19,15 | | | *a* |
| MRL (cm) | 1 | 24 | 77,71 | 17,55 | 2,461 | 0,065 | *A* |
| | 2 | 44 | 72,82 | 23,88 | | | *ab* |
| | 3 | 44 | 65,93 | 15,37 | | | *b* |
| | 4 | 44 | 72,84 | 14,08 | | | *ab* |
| ARL (cm) | 1 | 24 | 45,83 | 11,35 | 4,953 | 0,003 | *a* |
| | 2 | 44 | 45,09 | 13,62 | | | *a* |
| | 3 | 44 | 38,68 | 8,56 | | | *b* |
| | 4 | 44 | 39,23 | 7,03 | | | *b* |
| NS (number) | 1 | 96 | 10,29 | 5,75 | 6,495 | 0,000 | *a* |
| | 2 | 96 | 7,97 | 4,90 | | | *b* |
| | 3 | 96 | 7,89 | 4,60 | | | *b* |
| | 4 | 96 | 10,27 | 5,58 | | | *a* |
| LTC (cm) | 1 | 96 | 41,16 | 11,36 | 1,689 | 0,169 | *a* |
| | 2 | 96 | 41,86 | 11,98 | | | *a* |
| | 3 | 96 | 40,57 | 10,63 | | | *a* |
| | 4 | 96 | 44,14 | 12,98 | | | *a* |
| TCW (cm) | 1 | 96 | 25,27 | 9,29 | 0,629 | 0,597 | *a* |
| | 2 | 96 | 25,19 | 11,27 | | | *a* |
| | 3 | 96 | 24,03 | 8,60 | | | *a* |
| | 4 | 96 | 23,76 | 9,09 | | | *a* |

*Note: **LENGTH**: length of plant, **MRL**: maximum root length, **ARL**:average root length, **NS**:number of shoots, **LTC**:length of top crown, **TCW**:top crown width*

areas in Yusufeli Town, data regarding length of plant (LENGTH), maximum root length (MRL), average root length (ARL), number of shoots (NS), length of top crown (LTC), top crown width (TCW), was gathered and statistically analyzed. According to the analyses data about average root length of the plant and number of shoots was found to be significantly different ($p$<0.05). However no difference was found for the other data.

**Comparison of sample parcels according to measurement time :** The differences between observation times were investigated using 6 parameters. The magnitude of the existing differences was interpreted using Duncan's Multiple Test. The results are summarized in the following section and values are presented in Table 4. These parameters are important indicators that the Vetiver plant can survive in this particular area and act as a tool for preventing soil erosion.

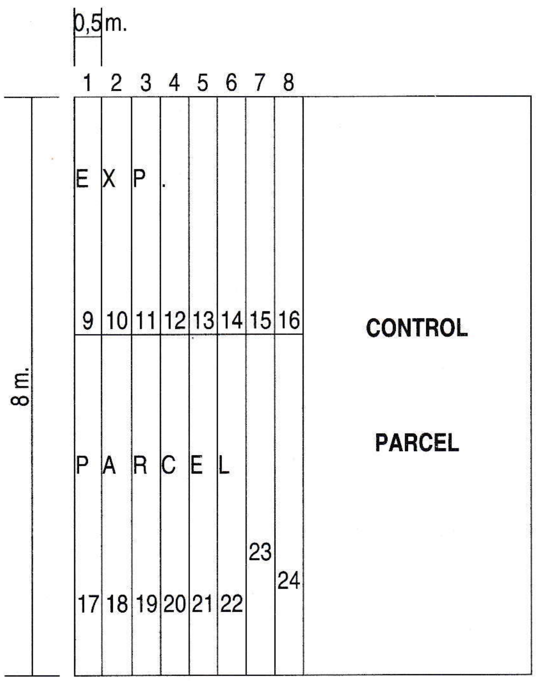
As a result of the observations and analysis of data obtained, significant differences were found according to measurement time for plant length ($p$<0.001, F=83.950) (Fig. 5), maximum root length ($p$<0.001, F=40,26306) (Fig. 6), average root length ($p$<0.001 , F=8,791) (Fig. 7), number of shoots ( $p$<0.001, F=46,720) (Fig. 8), length of top crown ($p$<0.001, F=45,27591) (Fig. 9) and crown width (($p$<0.001, F=40,89568) (Fig. 10).

**Discussion of length, root development and covering of vetiver grass**

• *Evaluation of the plant's development in length* : The best development was observed at experiment parcel 4 located at an altitude of 700-750 m and North-East exposition.

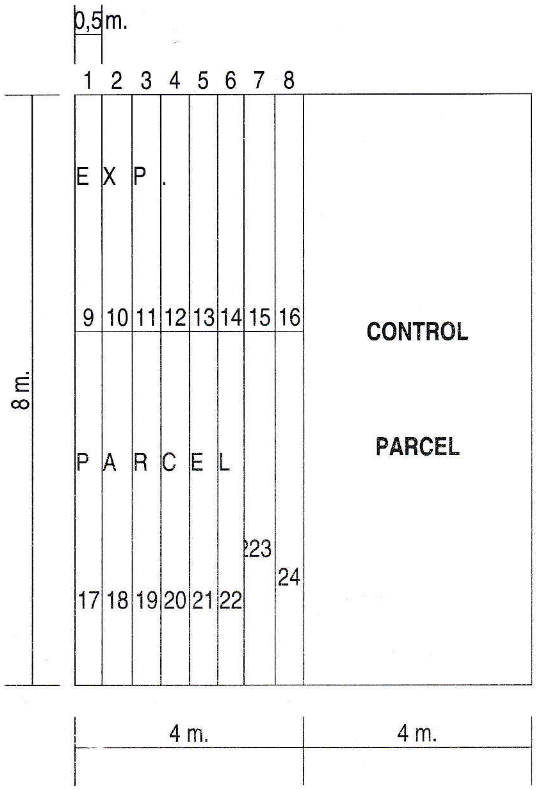
• *Evaluation of the plant's root development* : *Vetiver grass* shows the best root development at experiment parcels 1 and 2 located at an altitude of 750-800 m and Souh exposition.

**Experiment Parcel: 1**



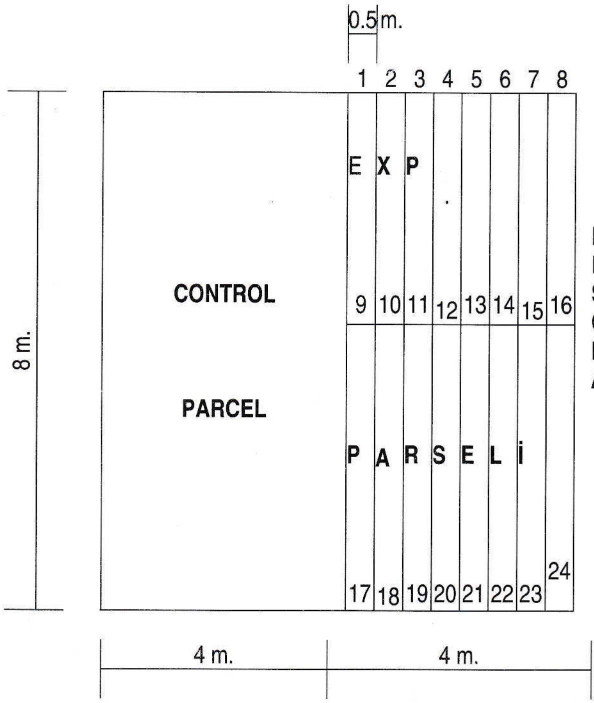

**Location:** Çakaloğlu
**Exposition:** South
**Slope:** 60 %
**Control Parcel:** 8x4: 32 m$^2$
**Experiment Parcel:** 8x4: 32 m$^2$
**Altitude Level:** 750-800 m.

**Experiment Parcel: 2**



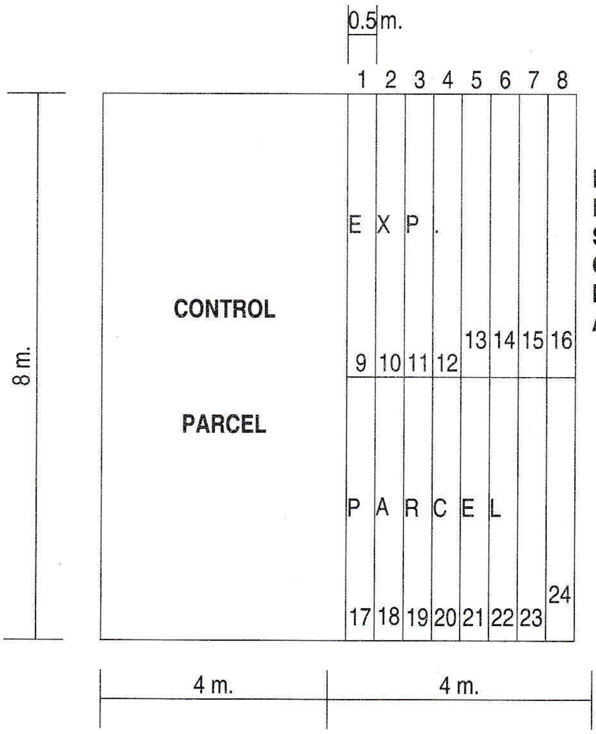

**Location:** Çakaloğlu
**Exposition:** South
**Slope:** 60 %
**Control Parcel:** 8x4: 32 m$^2$
**Experiment Parcel:** 8x4: 32 m$^2$
**Altitude Level:** 750-800 m.

*To be continued*




**Experiment Parcel: 3**

**Location:** Çakaloğlu
**Exposition:** North-East
**Slope:** 53 %
**Control Parcel:** 8x4: 32 $m^2$
**Experiment Parcel:** 8x4: 32 $m^2$
**Altitude Level:** 700-750 m.




**Experiment Parcel: 4**

**Location:** Çakaloğlu
**Exposition:** North-East
**Slope:** 53 %
**Control Parcel:** 8x4: 32 $m^2$
**Experiment Parcel:** 8x4: 32 $m^2$
**Altitude Level:** 700-750 m.

**Fig. 4 :** Experiment parcels.+

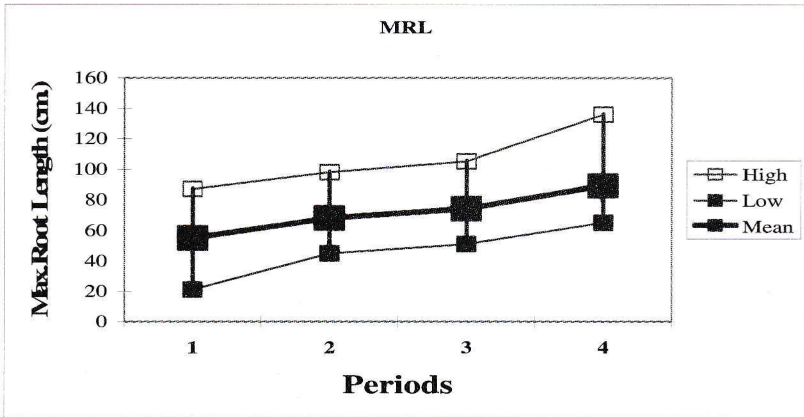



**Fig. 5 :** Comparison of plants according to length and observations periods.

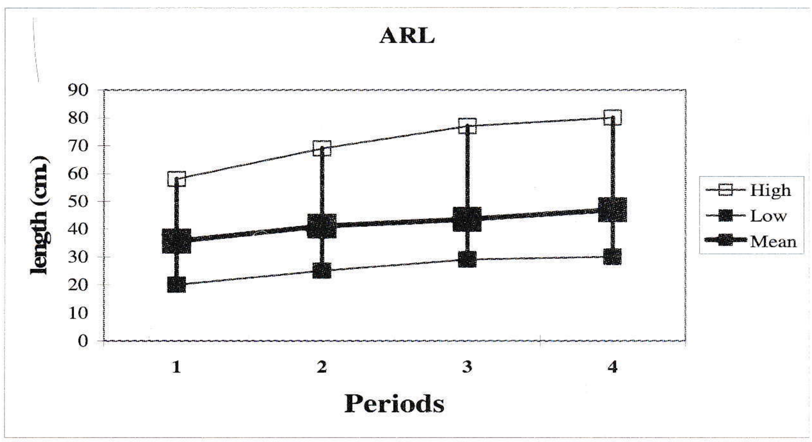



**Fig. 6 :** Comparison of plants according to number of shoot and observation periods.

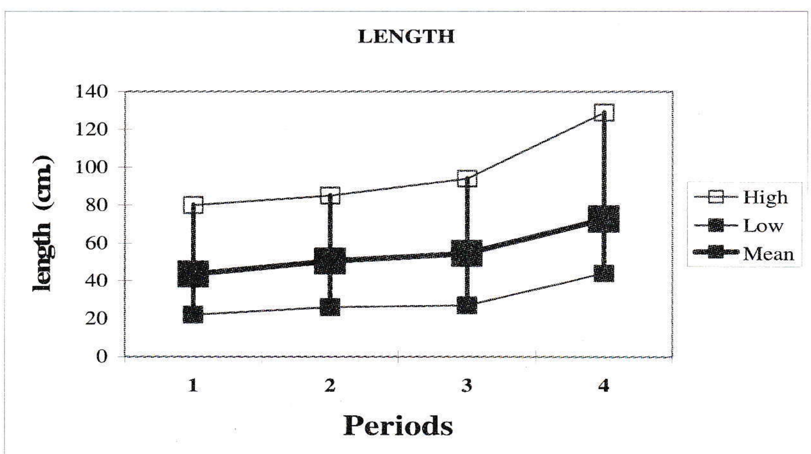



**Fig. 7 :** Comparison of plants according to length of top crown and observation periods.

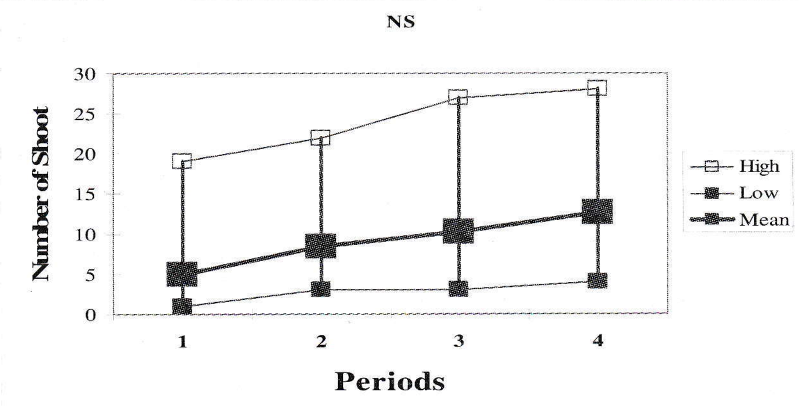



**Fig. 8 :** Comparison of plants according to number of shoot and observation periods.

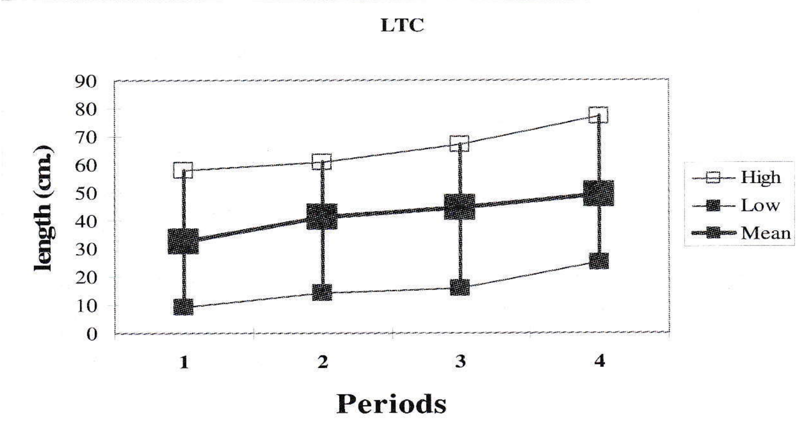



**Fig. 9 :** Comparison of plants according to length of top crown and observation periods.

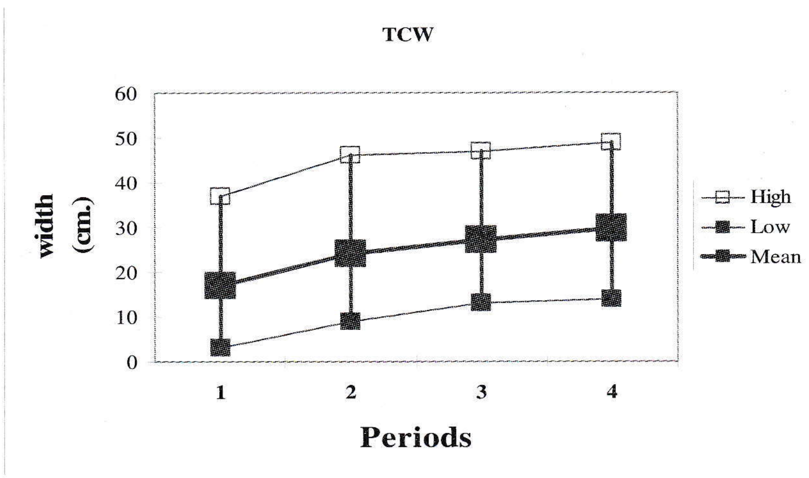



**Fig. 10 :** Comparison of plants according to top crown width and observation periods.

- *Evaluation of the plant's crown length and width : Vetiver grass* shows the best development of crown length at experiment parcel 4 located at an altitude of 700-750 m and North-East exposition. The best crown width development was observed at experiment parcel 2 located at an altitude of 750-800 m and South exposition.
- *Evaluation of the number of shoots : Vetiver grass* shows the maximum number of shoots at experiment parcel 4 at an altitude of 700-750 m and North-East exposition.

The soil at the research area is sandy clay. It was observed that the pH of the soil is 7.6-8.08, amount of lime is 4.17-8.36 and amount of organic material ranges between 0.70-4.84. An evaluation of the sensitivity of the soil against erosion according to the proportion of dispersion shows that the soil at all experiment parcels is weak against erosion.

The slope and the degree to which the four experiment areas facing North-East and South are covered with plants is very different from each other. Especially, the experiment site with South exposition is highly sloped with stony soil and nearly barren in terms of plant cover. At this area Çoruh river flows at 570 m and Mediterranean vegetation is dominant. However pseudomaki type plant growth is observed more at an altitude between 565-600 m (Davis, 1965). Naturally soil which is carried away with erosion causes the depositing of alluvium and sedimentation, slows down river flow and in addition effects water ecosystem negatively. Considering all these factors, precautions is to prevent the dam from filling up by holding surface soil.

North-East exposition site where the other experiment parcels (3 and 4) are located is different from South exposition sites. Although planting of trees by Yusufeli Forest Management in the area has reached success, this is not enough in itself. There is a lack of covering plants which would prevent surface erosion. Especially in arid regions, additional precautions to hold soil are necessary. In order to get successful results from planting trees, this should be supported by land covers and bushes.

Vetiver plant which has been tried for the first time in Turkey's Eastern Blacksea Region, has proved to have a wide vegetation spectrum with its adaptation to the Yusufeli town (Artvin) where it was planted. An application of the *Vetiver grass* in addition to existing method of tree planting at other regions would be beneficial in preventing soil erosion at slopes and providing stabilization of soil.

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