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# RELATIONSHIP BETWEEN SOIL PROPERTIES AND NATURAL REGENERATION PATTERN OF *JUNIPERUS EXCELSA* FOREST IN ZIARAT, BALOCHISTAN

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**Abstract**

In this study relationship of soil properties with the natural regeneration pattern of *Juniperus excelsa* forests of Ziarat was evaluated. Thirty stands were quantitatively sampled from different areas of Ziarat, Balochistan. Out of 30 stands we observed sufficient recruitment of Juniper seedlings in 27 stands. Diverse regeneration pattern was observed among and within sampling locations. Zizri Tore Sagran occupied highest seedling numbers i.e. 439 plants ha-¹ on north-east facing slope at 2948m altitude. Nishpa valley had 99 plants ha-¹ on south west facing slope at 2660m altitude, which is lowest density. In this study we computed 194±103 plants ha-¹ overall density and 67±21 $cm^2$ $ha^{-1}$ average basal area. Mild relationship was observed between seedling numbers and stand density while stand basal area and seedling numbers exhibited positive significant correlation ($r=0.281$, $p<.05$). Soil characteristics showed significant differences among the variables at significant levels of ($p<0.01$) and ($p<0.05$). Generally, the vegetative characteristics of *Juniperus excelsa* in the study area had significant correlation with the soil characteristics. The combine data showed balanced size class structures of J-shaped distribution.

**Key words:** Regeneration status, quantitative sampling, ecological characteristics, *Juniperus excelsa*, Ziarat, Balochistan

## Introduction

*Juniperus excelsa* M. Bieb. (*Cupressaceae*) grows in different parts of the world; naturally it exists in Anatolia, central and south Balkons, central and south Asia and east Africa (Athanasiadis, 1986). Adams (2008) stated that approximately sixty seven species of Juniper considered as most diverse group of conifers., all native to northern hemisphere although *Juniperus procera* Hochest. Along the Rift Mountains in East Africa into southern hemisphere this genus extended its growth southward (Adams, 2008). In Pakistan, this genus is represented by four species Viz, *Juniperus communis*, *J. squemata*, *J. turkistanica*, and *J. wallichiana* (Nasir *et al.*, 1976). Anon., (2006) listed this species as a threatened tree by IUCN Red List in Pakistan.

*Juniperus excelsa* is an evergreen tall shrub or tree up to 20 m, with a trunk as large as 2m diameter at breast height (dbh) level. Their vital needs are limited; they can survive in drought environmental conditions and has the ability like rocky coasts, mountain places, shallow and stony soils (Fisher *et al.*, 1995). Poor natural regeneration and slow growth is the chief characteristics of Juniper trees. They cover approximately 141,000 hectares. Khatak (1963) stated that Ziarat & Zarghun range near Quetta occupied 100,000 hectares for this species while the second largest forest of *Juniper* are found in Herboi hills of Kalat district. Fifty four percent (35325 hectare) of the Ziarat district occupied Juniper trees (Khatak, 1963).

The forest distribution is primarily governed by a complex of environmental factors including climate, soil, topography and biota (Ahmed, 1951). The vegetation of an area is true index of soil and climate. Most of the soils of northern Balochistan especially, the portion which containing *J. excelsa* forests are poorly explored (Rafi, 1965) and shallow profiles due to inadequate rainfall and steep slopes. Natural regeneration in Juniper forests of Juniper track was studied by Ahmed *et al.* (1989) and dynamics of Juniper forests was discussed by Ahmed *et al.* (1990a, b). However no research was undertaken to explore the natural regeneration in relation with soil factors. All living organism need nutrition, plants get nutrition from soil in the form of macro and micro elements. Sixteen essential nutrients are important for the regulation of metabolic function of plants. In this study comprehensive soil nutrient analysis is carried out to examine the role of nutrient in the distribution and composition of Juniper forest in Balochistan.

**Study area:** The study area is located in the north-eastern region of Ziarat district Balochistan at altitude ranging from 2000-3000 m which is bordered on the south by Sibi district, on the north by the district of Pishin, and on the east by Loralai distract. The whole sampling area occur at elevations between 1980-3350m and geographically extend between Latitude 30° 18' N to 30° 30' N and longitude 67° 54' E to 67° 57' E (Sarangzai *et al.*, 2012). The highest peak in the study area is Koh-Khalifa (3475m). The area is composed of irregular rugged ridges with steep terrain on comprising several narrow valleys, running from east to west.

Champion *et al.* (1965) categorized this area into dry temperate with irregular rugged ridges with steep terrain on comprising several narrow valleys, running from east to west. Holdrege (1947) stated that most of the part of Ziarat showed extreme cold in winter and pleasant weather in summer. 282 mm/year (mean annual rainfall) is mainly received in winter in the form of snow (Ali, 1966; Ahmed *et al.*, 1990a). Khattak (1963) predicted the snow fall from December to March. In February 1977 highest snow fall (82cm) was reported. Some showers also occur in July and August. The geological substrates include sedimentary rocks, ranging from cretaceous to recent in age (Shah, 1978).

## Materials and Methods

In order to get a fair idea of the density and distributions of Juniper seedlings, site selection was restricted as far as possible to mature Juniper forest with no recent signs of logging. Aspect and elevation of each stand was recorded (Table 1). Thirty stands were sampled using a circular quadrate of 2.5m radius following the method of Cottam & Curtis (1956) in various locations of the study area (Fig. 1). In each stand 10 plots were established and the number of Juniper of seedlings (up to 6cm dbh) recorded. Density and basal area were calculated according to Muller-Dombios & Ellunberg (1974) and Ahmed & Shaukat (2012). To seek the possible relation between Juniper seedlings $ha^{-1}$ and a few edaphic and community attributes, regression analysis was performed. The following six classes of diameter at the breast height (dbh) were established. 1st class was ranged from 0.5-1, 2nd 1.1-2…. and 6th 5.1-6.

In current study the sampled area is mostly occupied by monospecific forest of *Juniperus excelsa* and described by structural attributes on per hectare basis. 30 stands were randomly sampled at the elevation of 2000m to 3000m at 10 different sites (Table 1). Sampling sites are indicated in Fig. 1. Structural attributes of trees and seedlings are presented in Table 2. The behavior of Juniper regeneration was diverse between and within sampling sites. They were recorded in 27 stands out of 30 stands. Zizri Tore Sagran site showed the highest seedling density (439 plants $ha^{-1}$) at elevation of 2648m on west facing slope while the lowest density (99 plants $ha^{-1}$) was observed from Spera-ragha at the altitude of 2695m on north facing slope. Overall mean density was 215±78 plants $ha^{-1}$ while 67±21 $cm^2$ $ha^{-1}$ was the average basal area for all stands. The range of basal area was 0 to 143 plants $m^3$ $ha^{-1}$. Both the structural attributes of Juniper showed different values within a stand and in different sites. In some sites both the values were in reverse were true. There were also differences among various aspects in relation to the seedling density $ha^{-1}$ (Table 3). Highest density was recorded at north-east (439 individual $ha^{-1}$) and the lowest density was recorded towards west and south-west (99 individuals $ha^{-1}$).

**Table 1. Ecological characteristics of sampling sites of the study area.**

| S. No. | Main location | | Latitude (N) | Longitude (E) | Elevation (m) | Slope (o) | Exposure |
|---|---|---|---|---|---|---|---|
| 1. | Zizri Area | ZA | 30° 20' | 67° 42' | 2948 | 45 | W |
| 2. | Baba Kharwari | BK | 30° 20' | 67° 49' | 2645 | 36 | NW |
| 3. | Kotal Sarri | KS | 30° 22' | 67° 48' | 2630 | 29 | NE |
| 4. | Cautair Valley | CV | 30° 25' | 67° 47' | 2600 | 37 | S |
| 5. | Nishpa Valley | NV | 30° 17' | 67° 59' | 2639 | 46 | W |
| 6. | Pila Forest | PF | 30° 25' | 67° 37' | 2740 | 30 | NE |
| 7. | Sasnamana state forest | SF | 30° 24' | 67° 49' | 3116 | 38 | NE |
| 8. | Chasnak Aghburg | CA | 30° 27' | 67° 41' | 2880 | 30 | SE |
| 9. | Surghund | SG | 30° 20' | 67° 50' | 2510 | 29 | W |
| 10. | Spera-Ragha | SR | 30° 31' | 67° 14' | 2695 | 42 | N |


Fig. 1. Study area map of Ziarat, showing geographical coordinates.

**Results**

**Table 2. Summary of seedlings densities and basal area values from 30 stands of Ziarat, Balochistan.**

| Name & No. of stands | Density ($ha^{-1}$) | | | Basal area ($cm^2 ha^{-1}$) | | |
|---|---|---|---|---|---|---|
| | Min. | Max. | Mean ± SD | Min. | Max. | Mean ± SD |
| Zizri Area | 326 | 439 | 383 ± 80 | 32 | 44 | 38 ± 8 |
| Baba Kharwari | 156 | 269 | 213 ± 80 | 48 | 82 | 65 ± 24 |
| Kotal Sarri | 142 | 255 | 199 ± 80 | 62 | 108 | 85 ± 33 |
| Chautair | 0 | 198 | 99 ± 140 | 0 | 67 | 34 ± 47 |
| Nishpa Valley | 99 | 340 | 220 ± 170 | 42 | 143 | 93 ± 71 |
| Pila Forest | 241 | 312 | 277 ± 50 | 42 | 62 | 52 ± 14 |
| Sasnamana State Forest | 156 | 354 | 255 ± 140 | 40 | 91 | 66 ± 36 |
| Chasnak Aghburg | 127 | 184 | 156 ± 10 | 58 | 125 | 92 ± 47 |
| Surghund | 184 | 198 | 191 ± 10 | 58 | 76 | 67 ± 13 |
| Spera-Ragha | 99 | 212 | 156 ± 80 | 21 | 143 | 82 ± 86 |
| Over all mean | | | 215 ± 78 | | | 67 ± 21 |

**Key to abbreviations:** SD = Standard Deviation, Min = Minimum, Max = Maximum

**Table 3. Juniper seedling density ($ha^{-1}$) and basal area ($cm^2 ha^{-1}$) on various aspects.**

| Sr. No. | Sites | Aspect | Density ($ha^{-1}$) | | | Basal area ($cm^2 ha^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Mean ± SD | Min. | Max. | Mean ± SD |
| 1. | 3 | E | 156 | 184 | 170 ± 20 | 82 | 109 | 96 ± 19 |
| 2. | 6 | W | 99 | 269 | 184 ± 120 | 21 | 143 | 82 ± 86 |
| 3. | 5 | N | 156 | 312 | 234 ± 110 | 42 | 91 | 67 ± 35 |
| 4. | 2 | SE | 0 | 198 | 99 ± 140 | 0 | 67 | 34 ± 47 |
| 5. | 3 | NW | 142 | 354 | 248 ± 150 | 40 | 108 | 74 ± 48 |
| 6. | 6 | NE | 241 | 439 | 340 ± 140 | 32 | 62 | 47 ± 21 |
| 7. | 2 | ES | 127 | 241 | 184 ± 81 | 50 | 89 | 70 ± 28 |
| 8. | 3 | SW | 99 | 340 | 220 ± 170 | 42 | 143 | 93 ± 71 |

A positive significant relationship ($p>0.05$) was observed between seedling density with stand basal area while negative relationship was observed between tree and seedling numbers (Table 4). Seedling density $ha^{-1}$ was regressed with stand density $ha^{-1}$ were found non-significant while stand basal area $m^2$ $ha^{-1}$ were significant ($r=0.28$, $p<0.05$). Similarly water holding capacity ($r=0.19$, $p<0.01$) were significant and positively correlated while seedling density $ha^{-1}$ were non-significant with organic matter and altitude.

**Size class frequency distribution:** Size class frequency distribution of seedling is shown by histograms (Fig. 2). In this study the structure of the forests (seedling diameter <6 cm dbh) exhibited mix size classes and showed somewhat inverse J shaped distribution (Fig. 2). Some stands showed similar seedlings density but show varied size structure. Gaps were evident in some stands due to absence of particular size plants. Lack of recruitment and mortality could be the reason of gaps in particular size classes in particular time period. Anthropogenic disturbance could be another reason of gaps in size class structure.

**Soil analysis:** There is marked variability was observed in soil properties. Electrical conductivity of soil from Baba Khurwari and Surghund were 2.74 and 1.49 respectively (Fig. 3). The highest and lowest organic matter was observed in Chashnak, Aghburg and Chautir Valley 3.74 and 2.59%, respectively. In the whole study area the soil was alkaline (7.9 to 8).

**Table 4. Summary of regression analysis of Juniper seedling $ha^{-1}$ with structural and soil properties.**

| S. No. | Variables | Regression equation | r | Significant value |
|---|---|---|---|---|
| 1. | Stand density | y = 0.1418x + 237.45 | 0.70 | NS |
| 2. | Stand basal area | y = 0.0897x + 60.565 | 0.28 | * |
| 3. | Water holding capacity | Y=0.0163x+32.945 | 0.197 | ** |
| 4. | Organic mater | Y=0.0005x+3.2965 | 0.092 | NS |
| 5. | Altitude | Y=0.2228x+2674.3 | 0.145 | NS |
| 6. | Seedling density/silt | Y=-0.0114x+22.584 | 0.157 | *** |
| 7. | Seedling density/sand | Y=-0.0242x+69.997 | 0.091 | NS |
| 8. | Seedling density/clay | Y=0.0093x+13.642 | 0.179 | *** |
| 9. | Seedling basal area/silt | Y=-0.0129x+21.249 | 0.069 | ** |
| 10. | Seedling basal area/sand | Y=-0.0109x+66.058 | 0.055 | NS |
| 11. | Seedling basal area/clay | Y=0.0266x+10.032 | 0.197 | ** |

**Note:** = Multiple r-value; NS= Non-significant; Significant level * =$p<0.05$; ** =$p<0.01$; *** $p=0.001$

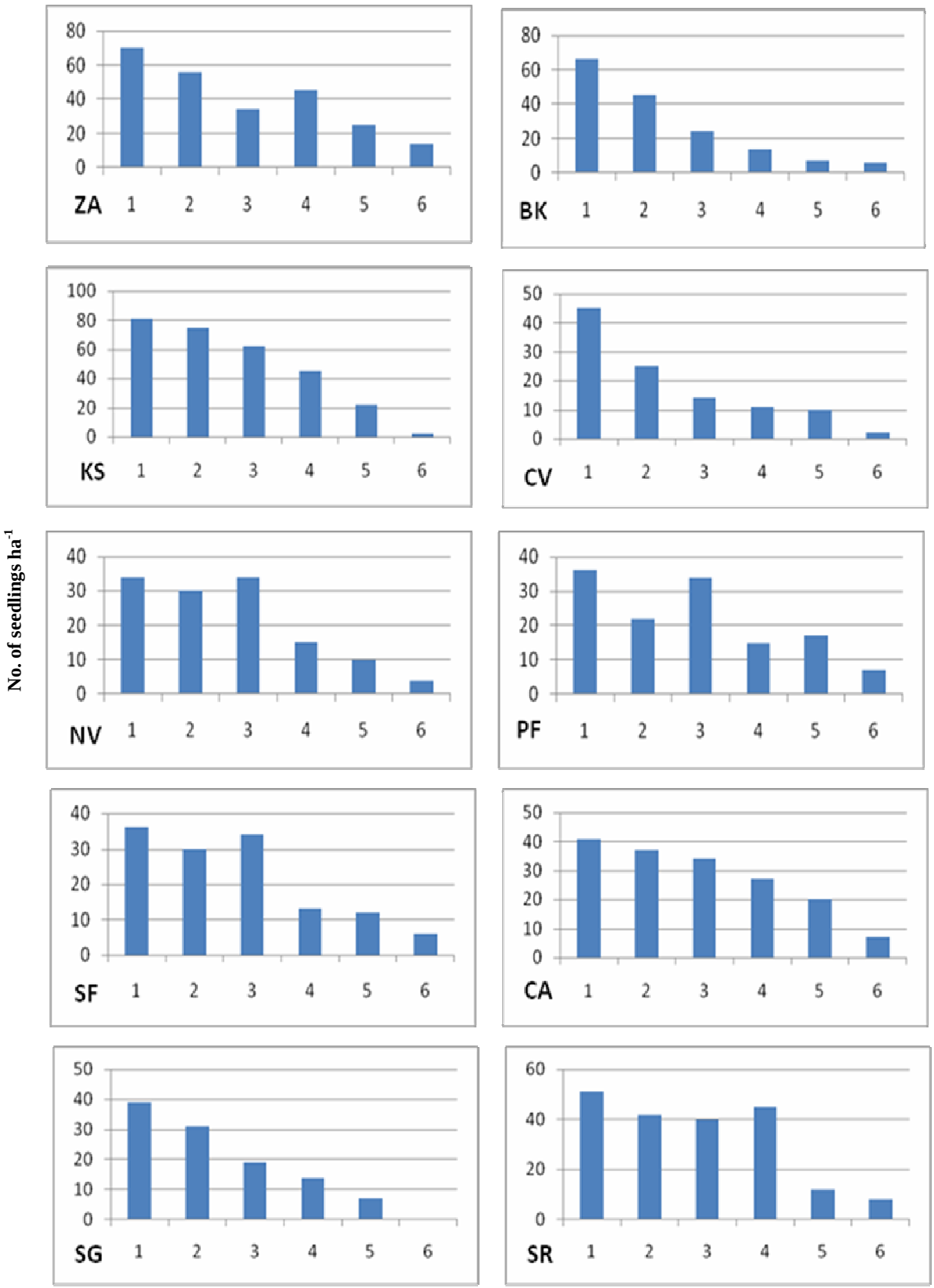


Fig. 2. Number of seedlings per hectare of various Juniper tree species within each stand of the study area (for area code see Table 1).

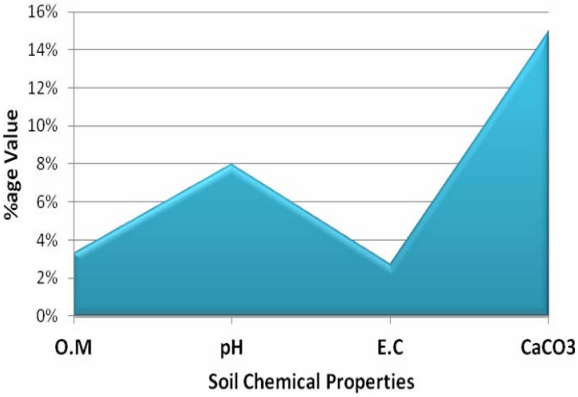


Fig. 3. Shows soil chemical characteristics of study area.
OM = Organic matter; pH = Hydrogen concentration; EC = Electrical conductivity; $CaCO_3$ = Calcium carbonate.

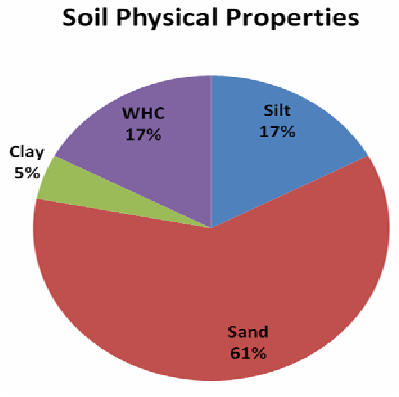


Fig. 4. Overall percentage values (mean of 30 stands) of soil physical characteristics in the study area.
WHC=Water holding capacity.

Physical properties of soil are also varied in most of the stands (Fig. 4). Sandy-loam was the predominant soil type. Silty loam soil texture was observed in Tore Sokhar while sandy loam was observed in other stands. Chashnak Aghburg and Zizri sites exhibited 11.4 and 21.4% $CaCO_3$ respectively. Significant relationships were observed between the Juniperus excelsa seedlings with edaphic attributes. Chashnak Aghburg and Nishfa valley exhibited highest and lowest water holding capacity 39 and 20%, respectively. The highest and lowest clay percentages were in Surghund and Baba Khrwari 18 and 5%, respectively. The highest silt percentages were in Chashnak Aghburg was 22%. Sand percentages in Nishfa valley and Chashnak Aghburg were found as 78 and 50%, respectively.

## Discussion

Regeneration of Juniper tree in the forests of Ziarat is strongly affected by anthropogenic disturbance. The rate of natural regeneration is low. Many authors pointed out that *Juniperus excelsa* is widely spread in Ziarat area. This well tolerated species prefer to grow in this harsh and drought environment. Pure, open and unstratified stands of *J. excelsa* recorded from the study area. It is evident that anthropogenic disturbance in the study area causes variations in the floristic composition, distribution and regeneration pattern of vegetation and also causes soil erosion.

Juniper seedlings were recorded frequently with a canopy cover of dense shrubs or with small trees, most probably due to shade or improved soil condition (Ahmed *et al.*, 1989). The seedlings fail to survive without canopy cover as it was observed when the infected trees were removed by Balochistan forest department in past. Similar observation have made on the *Nothofages solandri* (Wardle, 1969) and *Agathus australis* (Ahmed, 1984) in New Zealand. Sheikh (1985) also reported higher survivorship's in planted Juniper seedling under shade conditions. Sarangzai (2000) supported the concept of Juniper seedlings are shade dependent in early stages of their establishment. Siddiqui *et al.* (2014b; 2014c) studied the soil and nutrient concentration from moist temperate belt and topographic and edaphic control of arboreal vegetation. These studies give the clear comparison of ecologically different areas. The study of Milios *et al.* (2007) in Juniper forests of Greece showed that the regeneration of seedling was most frequent under canopy cover.

Soil and biotic factors are related to each other change in anyone of these components might cause a change in other associated components. Seedling populations recorded in current study ranging from 99 to 439 individuals $ha^{-1}$ with an average of 215±78. Previously recorded 16 to 229 individuals $ha^{-1}$ by Sarangzai *et al.* (2004), which is much lower than our present data. The differences may be explained by assuming that earlier estimates were based on disturbed and undisturbed stands while we selected least disturbed stands. Seedling density were higher where conditions are favorable and having no human disturbances.

Physical properties of soil markedly affect water content, soil fertility, soil erosion, soil temperature and water holding capacity. Sand fraction represents the main part of the soil sampled analyzed and ranges between 50 to 78%. These findings are also supported by the results obtained by Sarangzai *et al.* (2004) and Hussain & Rizvi (1974). The soils of the study area is rocky nature that indicated by the presence of silt and clay in low quantity, low and medium water holding capacity, low amount of organic matter and minimum soil moisture. Siddiqui *et al.* (2011; 2014a) recorded the above parameter in high quantity from many forests of moist temperate areas of Himalayan & Hindukush range of Pakistan. In both the studies the results are contrary; it could be due to difference in climatic region, because Ziarat is included in dry temperate area. Sarangzai *et al.* (2004) reported similar results from 66 stands of Juniper forest which is due to less quantities of humus or it may be due to erosion of the upper horizons of the soil.

## Conclusions

In a nutshell the forests of Ziarat are under severe threat and some of the species are endangered, it could be due to harsh and drought environmental condition, degradation of biotic/abiotic factors and anthropogenic disturbance. Relationship between the seedling density and

basal area with topographic and some soil factors were positively correlated but non-significant. This may be the result of human disturbances, animal grazing and effect of drought conditions in these forests. It is concluded that these forest have degraded extensively and needs an immediate and permanent conservation programs.

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