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# Structure and natural dynamics of *Dodonaea viscosa* communities in Malakand division, Pakistan

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**Key words:** *Dodonaea viscosa*, Community structure, Dynamics, Environmental factors, Cluster analysis, ordination (NMS, DCA).

**Abstract**

The present study aims to investigate the structure and natural dynamics of *Dodonaea viscosa* in Malakand division. For sampling a 10x10m quadrat was used and 28 stands were sampled. Various phytosociological attributes of the species were calculated. The IVI of 27 plants species was subjected to Cluster Analysis and Ordination which results into the formation of 5 plants communities dominated by *D. viscosa*. NMS ordination axes 2 was significantly correlated with slope, Potassium and clay % while axes 1 was only found in significant correlation with clay particles. DCA axes 1 was significantly correlated with slope, pH, and organic matter while, axes 2 was correlated significantly with water holding capacity, Nitrogen contents and organic matter. Difference among the density and cover/ha of *D. viscosa* and associated species in different communities is due to the difference in the values of environmental factors, highest density/ha of *D. viscosa* was recorded at high altitude, high slope angle, organic matter, water holding capacity, clay %, and Nitrogen content in the soil. *D. viscosa* mostly grows in calcareous soils with a texture loamy Sand to sandy loam with low phosphorus, marginal nitrogen and potassium contents. *D. viscosa* can grows at any aspect but it favors areas which receive full sunlight. The height and cover sized classed showed a multi-model pattern (reverse J- shaped, L-shaped, Bell-shaped almost bell shaped and Un-even). The difference in pattern of size classes is due to anthropogenic activities, competition, regeneration pattern, difference in the soil and micro climatic condition of the site.

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## Introduction

The classification of vegetation communities based on structure and functional parameters is necessary for the determination of natural dynamics of vegetation (Grime 2001). Quantitative data helps in understanding the status, degree of usefulness and intensity of the anthropogenic pressure on each species. Phytosociological information about each individual plant species is essential for understanding their ecology and establishing conservation management policies (Dhankhar *et al.* 2011). About 4.8% area of Pakistan is covered by forests (Ahmed *et al.* 2010; Khan 2012) which provide fodder and shelter for livestock, fuels-wood as well as folklore medicines for local community (Nabi *et al.* 2015). Due to the influence of a number of interacting factors such as climatic change topography, edaphic factor andanthropogenic disturbance, (Jan 2011) the composition of natural vegetation is changed day by day (Wahab 2011). As a result of increasing population, unavailability of alternative source for fuel purposes, over grazing and fodder demand not only disturb the communities' structure but also reduced species diversity of the area (Asner *et al.* 2006). Communities' structure and diversity pattern is mostly influenced by ecological factors such as altitudinal gradient, slope aspect and annual rainfall of the area (Shariatullah 2013; Khan 2012). The physical and chemical properties of the soil also greatly affect the distribution of vegetation communities (Zare *et al.* 2011; Khan and Bibi 2013).

There are mainly two groups of multivariate analysis namely Cluster Analysis and ordination which are used for the grouping and arrangement of sampling plots along ordination axes (Palmer 2005). There are different ordinations techniques such as Two-Way Indicator Species Analysis (TWINSPAN), Principal Component Analysis (PCA), Bray-Curtis Ordination, Detrended Correspondence Analysis (DCA) and Non-metric Multidimensional Scaling (NMS). Among these DCA is widely used for the analysis of vegetation communities (Panthi *et al.* 2007). DCA ordination not only tells us about the pattern in complex data set but, also geared to species and sample (McCune and Grace 2002).

Beside DCA ordination another technique which is mostly used in the field of ecology is Non-numeric Multidimensional Scaling (NMS). It is usually suitable for the analysis of ecological data set which is no normal, arbitrary (Clarke 1993). This method is not only used as an ordination technique, but as a method for the assessment of dimensionality of the data set (McCune and Grace 2002). NMS tries to linearize the relation between environmental and ecological distance, letting off zero truncation problem (Beals 1984).

The application of multivariate techniques such as classification and ordination for the analysis of ecological data are recently introduced in Pakistan and for the first time used by Shaukat and Qadir (1971). After that, Ahmed and Qadir (1976), Shaukat *et al.* (1980), Peer *et al.* (2001), Hussain *et al.* (1993), Maria *et al.* (2004), Enright *et al.* (2005), Riffat and Hussain (2007), Ahmed *et al* (2009), Wazir *et al* (2008), Siddiqui *et al.* (2009), Ahmed *et al.* (2011), Shaheen and Shinwari (2012), Khan *et al.* (2011) , Ahmad *et al.*(2011), Wahab (2011), Khan *et al.* (2013), Ali (2013), Shariatullah (2013) and Khan *et al.* (2014) explored the structure and natural dynamics of vegetation communities using classification and ordination techniques. While, the data is conducted mostly on overall vegetation of the particular area or either on single tree species but less attention is given to shrubs and no information is available on the detailed structure and natural dynamics of *Dodonaea viscosa* dominated communities in Malakand division. Therefore an attempt is made to conduct detailed study on the structure and natural dynamics of *Dodonaea viscosa* in relation to environmental and edaphic variables.

## Materials and method

*Introduction to study area*

Malakand division is situated in the northern side of Khyber Pakhthunkhwa and southern aspect of Gilgit Baltistan. It is located in the Hindukush range of Pakistan and positioned at latitude 35°30 N and 72°00 E longitude and at altitude between 700-7000 m asl.

Its protected area comprised of 952 km² (Shariatullah 2013) Out of the total area of Malakand division about 4631 hectare area is covered by forests which fulfill the need of the local inhabitant for timber and fuels woods etc (Nabi *et al*. 2015). The climate is varying with the elevation in different districts of Malakand division and is broadly described as continental, which is hot during summer and cold in winter (Wahab *et al.* 2008). The area has four distinct seasons. The summer season is moderate and warm; June and July are hot months in which the mean maximum and minimum temperature has been recorded as 32.52 C and 15.67 C respectively. The winter season is cold and severe, December, January and February are very cold months and the temperature generally falls below freezing point (Khan 2012). The mean maximum and minimum temperature in January has been recorded as 11.22 C° and –2.39 C° respectively. The precipitation is received throughout the year in the form of rain, snow and hail. The maximum rainfall has been recorded in March (242.22) mm while the relative humidity is quit high throughout the year.

*Field Method*

The area of different districts of Malakand division were search in the years (2011-14) for *Dodonaea viscosa* communities. Sampling of *Dodonaea* communities were taken in least disturbed areas. Different quantitative methods were applied for sampling *Dodonaea* communities following Mueller-Dombois and Ellenberg (1974).

*Design of sampling points and data collection*

For the collection of data on phytosociological attributes of Dodonaea 10x10 meter points were selected and 10 quadrats were taken randomly at each sampling stand and height and cover of all species present inside each quadrat were measured in cm (Cox 1990). Elevation was measured in meter obtained through GPS (global positioning system) and aspect was determined through magnetic compass while, Clinometer' was used for slope angle of the sampling site following (Khan 2013).

The plants specimens were collected and identified with the help of flora of Pakistan (Nasir and Ali 1972; Ali and Qaisar 1995-2007).

*Soil samples collection*

One kg Soil samples were collected in polythene bags from four different places in each stand up to a depth of 30 cm.

*I: Statistical Analysis*

The IVI of all species and the data of environmental variables were subject to PC-Ord software for cluster analysis and Ordination. The aspect of the sampling stands were taken in numerical codes following (Palmer (2005; Khan 2011). The data of environmental variables of the sampling stands was correlated with DCA and NMS ordination axis. The height and cover of *Dodonaea* viscosa was classified in different classes on per hector basis (Shariatullah 2012). For the representation of pattern of individuals in communities groups a polynomial curve was fit to the entire diagram (Rahman 2013). Pearson product movement correlation and regression analysis were applied for the interpretation of vegetation data.

*II: Laboratory Methods*

*Vegetation data analysis*

The data of vegetation communities was analyzed for phytosociological attributes like frequency, relative frequency, density, relative density, cover, relative cover, Importance values (IVI), density/ha and cover/ha. The soil samples collected from different sampling sites were thoroughly mixed labeled and was taken to the agriculture research Centre Takhtaband (swat) for analysis of physical and chemical parameters. Soil water holding capacity was determined following. 1:5 soil water suspensions were used for the determination of pH of the soil samples following Black (1965). Silt, sand and clay) % were calculated through hydrometer method following Bouyoucos (1936). Organic matter of the soil was determined following Walkley (1947), while acid base neutralization method was used for lime contents of the soil (Rahman *et al* 2012). Bingham (1994) method was used for the determination of phosphorus,

while Soltan-purand Schwab (1977) were followed for the determination of N and K while, MNo3 and AB-DTPA was used for the extraction of from Basic soil (Sultan-purand Schwab 1977).

**Results**

*Floristic composition*

Floristically the sampling sites were dominated by 27 plants species belong to twenty one families and twenty six genera. Six families shared two species (for each) are dominant families in term of their species are family Asclepidaceae Lamiaceae, Papilonaceae and Rosaceae. The remaining families are monspecific and each family has contributed single species to the floristic composition of the sampling area. Except family Asclepidaceae every one of the remaining families is represented by a single genus.

*Classification of Vegetation Communities' through Ward's Cluster Analysis*

Dendrogram results from Ward's cluster analysis showing different groups of vegetation, On the basis of stands group I is the largest include 9 stands present at the top of Dendrogram. Fig. 1.2 represent the two way cluster Dendrogram of the vegetation data in *Dodonaea viscosa* dominated communities. On one side it represent stands while on the other side represent species distributed in different groups. The black dots represent the presence of species distributed in the study area. Based on importance values the details of different communities groups are summarized below.

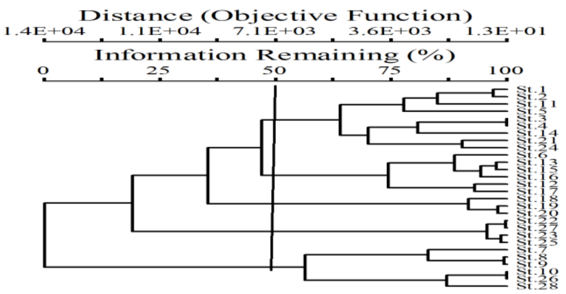


**Fig. 1.** Cluster Dendrogram derived through Ward's Cluster Analysis showing different plants communi-ties.

*Group I: Dodonaea-indegopera Community*

It is the largest group consists of 9 stands and 20 species in which *Dodonaea viscosa* is the dominant species followed by *indegopera gerardiana* and *Gymnosporia*. The IVI mean value of *Dodonaea viscosa* is 29.4±4.6, *Indigoferagerardiana* 13.7±1.9 and *Gymnosporia*. 8.7±2.1%.

Among the remaining 17 species of this group the ivi mean value of *P. rugosus* is 8.3±1.1%, *Olea cuspidate* 7.1±1.5%, *Daphne mucronata* 3.4±1.4, *Justacia adhatoda* 4.2±1.7%, *Cotoneaster microphyllum* 5.8±2.0%, *Mallotusphiliphinsis* 2.8±1.9% and *Accacia modesta* 2.9±1.5% as depicted in table (3.1).

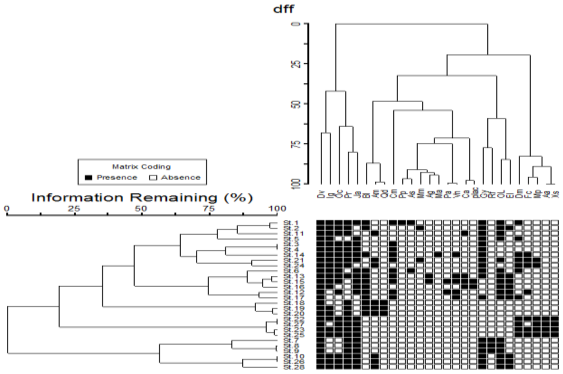


**Fig. 2.** Two way clusters Dendrogram representing the presence and absence of species in different sampling stands.

The ivi mean value of *Berberis lyceum* and *Otostegia limbata* is same as 2.3±1.2 % while, that of *Ficuscarica* is 1.3±1.0 and Cotoniaster microphylus 1.0±0.7%. *Artemisia scoparia, Periphloca aphylla, Eucalyptus lanceolatus, Vitex negundo, Myrsine Africana and C. astralis* are other species of group I and their IVI mean values ranged from 0.7±0.7 to 0.1±0.1% (table 1).

*Group II: Dodonaea-Indegopera Community*

This group consists of 6 stands and 17 species. Similar to group I the leading dominant species of this community is *Dodonaea viscosa* with mean ivi (33.00±0.91)% and co-dominant species is *I. gerardiana* (11.50±2.90)%. Among the remaining species of this group the ivi of *O. limbata* is 10.50±0.65, *B. lyceum* 7.75±0.85% and *C. microphyllum* 7.00±2.42%. Among the remaining 12 species the ivi of *C. astralis* is 6.25±2.25%, *J. adhatoda* 6.00±0.41%, *E. lanceolatus* 5.25±1.93%, *Gymnosporia* 3.00±2.38%, *A. gracilis* 2.50±2.18%, *P. rugosus* 2.00±1.68%, *O. cuspidate* 1.50±0.65% and *V. negundo* 1.25±0.95%. The ivi of the remaining four is less than 1% (Table 1)

*Group III: Dodonaea-Berberis Community*

Group 3 consist of three stands and six species. The dominant species of this community is *D. viscosa* while the co-dominant species is *B. lyceum*. The ivi mean value of *D. viscosa* is 45.67±0.67% which is the largest value as compared to other groups. The mean ivi of *B. lycium is* 13.67±2.73% followed by *P. rugosus* (13.33±2.33)% and *A. modesta* (12.33±2.33)% (Table 1).

*Group IV: Dodonaea-Aillanthus Community*

Group IV consist of four stands and10 species in which *Dodonaea viscosa*is dominant species sharing 25.75±2.46% ivi while the co-dominant species is *A. altissima* (12.25±1.65)%. Among the other species of this group the ivi of *J. adhatoda*is 10.00±1.08%, *D. mucronata* 12.25±1.65%, *O. cuspidate* 9.25±0.48% *M. philiphinsis* 8.00±1.22%, *P. rugosus* 7.00±0.41%. The result also shows that *A. altissima* and *X. stramarium* are the species which are only found in the sampling stands of group IV the ivi of the remaining specie is summarized in table (1).

*Group V: Dodonaea-Gymnosporia Community*

Group V is also dominated by *Dodonaea viscosa* but the ivi mean value of *Dodonaea* viscosa (23.67±4.78) % is low as compared to other groups. Out of 10 species of group V *Gymnosporia* is the co-dominant species sharing 14.67±2.38% ivi mean value with group V followed by *P. rugosus* (14.00±2.35) %, *J. adhatoda* (13.83±1.05) %, *O. limbata* (13.50±1.38)% and *R. fruticosus* (5.83±2.63)%. *I. gerardiana*, *E. lanceolatus O. cuspidate* and *A. modesta* are the remaining four species belong to six stands of group V and their ivi mean values are shown in table (1).

**Table 1.** IVI mean values of species in different group's results from Ward's Cluster Analysis.

| Species Code | Species Names | Group I Mean±SE | Group II Mean±SE | Group III Mean±SE | Group IV Mean±SE | Group V Mean±SE |
|---|---|---|---|---|---|---|
| Dv | *Dodonaea* viscose | 29.4±4.6 | 33.00±0.91 | 45.67±0.67 | 25.75±2.46 | 23.67±4.78 |
| Bl | Berberis lyceum | 2.3±1.2 | 7.75±0.85 | 13.67±2.73 | - | - |
| Ig | Indigofera gerardiana | 13.7±1.9 | 11.50±2.90 | 9.00±4.93 | 3.75±1.65 | 4.67±2.16 |
| Oc | Olea cuspidate | 7.1±1.5 | 1.50±0.65 | - | 9.25±0.48 | 3.50±1.63 |
| Pr | P. rugosus | 8.3±1.1 | 0.75±0.75 | 13.33±2.33 | 7.00±0.41 | 14.00±2.35 |
| Cm | Cotoneaster microphyllum | 5.8±2.0 | 7.00±2.42 | - | - | - |
| Dm | Daphne mucromata | 3.4±1.4 | 0.75±0.75 | - | 9.50±0.87 | - |
| Gy | Gymnosporia | 8.7±2.1 | 3.00±2.38 | - | - | 14.67±2.38 |
| Pp | Periphlocaaphyla | 0.1±0.1 | - | - | - | - |
| OL | Otostegialimbata | 2.3±1.2 | 10.50±0.65 | - | - | 13.50±1.38 |
| Ja | Justiciaadhatoda | 4.2±1.7 | 6.00±0.41 | - | 10.00±1.08 | 13.83±1.05 |
| As | A. scoparia | 0.1±0.1 | 0.75±0.75 | - | - | - |
| Mm | Cotoniastermicrophylus | 1.0±0.7 | - | - | - | - |
| El | Eucalyptus lanceolatus | 0.2±0.2 | 5.25±1.93 | - | - | 3.83±1.72 |
| Rf | Rubus fruticosus | - | - | - | - | 5.83±2.63 |
| Am | Accacia modesta | 2.9±1.5 | - | 12.33±2.33 | - | 2.50±1.20 |
| Ca | C. astralis | 0.7±0.7 | 6.25±2.25 | - | - | - |
| Vn | Vitex negundo | 0.2±0.2 | 1.25±0.95 | - | - | - |
| Fc | F. carica | 1.3±1.0 | - | - | 4.00±1.41 | - |
| Ag | Asparigus gracilis | - | 2.50±2.18 | - | - | - |
| Ma | Myrsine Africana | 0.6±0.6 | - | - | - | - |
| Plac | Plactrenthus rugosus | - | 2.00±1.68 | - | - | - |
| Qd | Quercus dilatata | - | - | 6.00±1.53 | - | - |
| Mp | Mallotus philiphinsis | 2.8±1.9 | - | - | 8.00±1.22 | - |
| Aa | Aillanthus altissima | - | - | - | 12.25±1.65 | - |
| Xs | Xanthium stramarium | - | - | - | 0.50±2.40 | - |

*Environmental variables related to various plants communities derived through Ward's cluster analysis*

The results of environmental variables shows that the sampling stands of *Dodonaea* communities of group I, III and V are situated at high altitude with a mean value of 1011.9±101.4m, 1083.7±232.4, 1172.8±155.0 while vegetation of community II is situated at low altitude. The slope angles of sampling sites of group III is large, (53.3±6.7)° while that of group IV is small (28.5±2.2)° than all other communities groups. The values of aspect of the sampling sites are given in table (2). The water holding capacity of the soil of group III is high 11.0±4.4/10gm followed by group IV and group I. based on pH mean values the soil belongs to the *D. viscosa* dominated communities of groups (I, II, III and V) was acidic while, that of group IV was basic soil with a mean value 7.0±0.2. The soil organic matter of all sampling sites was marginal but the mean value of organic matter in group V was smaller and that of Group III was greater than all the vegetation groups (Table 2). Lime % content of the sampling soils of group I is high than all other groups followed by group V the results also shows that all *D. viscosa* communities belong to calcareous soil. Total available nitrogen contents mean value was (1.3±0.1) in community II which is the lowest value but high mean value of total nitrogen was found in group III (2.8±0.5). The results show that nitrogen content of all the communities groups is marginal except group II in which it is low. Phosphors contents (mg $kg^{-1}$) of soil in community I is 2.4±1.2mg $kg^{-1}$, in II it is 2.0±0.2mg kg-1 while in the soil of group (III, IV, and V) is (2.8±0.5, 2.6±0.5 and 1.7±0.2)mg $kg^{-1}$ respectively which shows that the phosphors contents are low in the soil of all sampling sites but marginal in group V.K (mg $kg^{-1}$) contents is 114.2±23.2 in the soil in group I which is low than group IV but high than the soil of all other communities. The mean values of K (mg $kg^{-1}$) soil contents are marginal in all groups while adequate in the soil of community IV. Among the physical parameters % of Silt particles is high than Sand (64.0±3.7) % Clay (5.5±0.9) % in community group I, which shows that the soil is loamy in texture. Among the soil of other groups the % mean values of sand particles is high than silt and clay Particles.

**Table 2.** Mean Values of Soil and environmental variables related to different plants Communities.

| S/No | Environmental variable | Group I | Group II | Group III | Group IV | Group V |
|---|---|---|---|---|---|---|
| 1 | | Mean±SE | Mean±SE | Mean±SE | Mean±SE | Mean±SE |
| 2 | Elevation | 1011.9±101.4 | 461.2±124.6 | 1083.7±232.4 | 842.5±56.3 | 1172.8±155.0 |
| 3 | Slope | 49.0±4.4 | 50.8±4.0 | 53.3±6.7 | 28.5±2.2 | 41.5±5.4 |
| 4 | Aspect | 1.3±0.3 | 1.5±0.5 | 3.0±0.0 | 2.0±0.4 | 2.5±0.3 |
| 5 | water hc/10gm | 4.2±0.6 | 3.2±0.3 | 11.0±4.4 | 5.8±2.1 | 2.5±0.5 |
| 6 | pH | 6.4±0.4 | 4.6±0.7 | 6.2±0.1 | 7.0±0.2 | 6.2±0.3 |
| 7 | %OM | 1.4±0.2 | 1.0±0.0 | 1.5±0.3 | 1.4±0.3 | 0.9±0.1 |
| 8 | %Lime | 14.0±1.4 | 10.9±1.2 | 13.2±2.2 | 12.3±1.9 | 13.4±2.0 |
| 9 | Tot.N (g $kg^{-1}$) | 2.3±0.3 | 2.0±0.2 | 2.8±0.5 | 2.6±0.5 | 1.7±0.2 |
| 10 | P (mg $kg^{-1}$) | 2.4±1.2 | 0.6±0.1 | 1.9±0.6 | 1.9±1.4 | 2.9±1.5 |
| 11 | K (mg $kg^{-1}$) | 114.2±23.2 | 63.7±5.3 | 94.0±8.7 | 164.5±37.8 | 110.0±37.6 |
| 12 | Sand % | 64.0±3.7 | 70.0±2.4 | 55.7±4.9 | 62.8±8.4 | 65.1±5.6 |
| 13 | Clay % | 5.5±0.9 | 4.0±0.5 | 8.3±3.6 | 8.5±2.2 | 7.7±1.4 |
| 14 | Silt% | 25.6±3.5 | 13.0±1.1 | 36.0±2.1 | 28.7±6.4 | 27.6±5.0 |

*Correlation among environmental variables*

The results of Pearson correlation shows that there is a strong significant relationship between soil pH and elevation, (r=0.425 p>0.05), phosphorus and elevation (r=.599, p>0.001), potassium and elevation (r= 0.394p>0.05) as well as silt particles and elevation of the sampling stands at the given probability level (r= 0.517, p>0.01).

The r value of cross correlation shows that there is a negative significant relationship between slope angle of the sampling sites and phosphorus (r= -0.408, p>0.05), slope angle and potassium contents of the soil (r= -0.544, p>0.01) while aspect of the sampling sites was found in positive significant relationship with clay particles (r= 0.465, p>0.01).

A significant relationship is also found between pH and lime content (r= 0.513, p> 0.01), pH, clay % (r=0.418 p>0.01) and pH and silt % of the soil at (r=0.55, p> 0.01) probability level. A significant relation was also found between lime % and clay particles and lime % with silt content of the soil (r=0.640, 0.641, P> 0.001), while a negative significant relation was found between lime % and sand particles of the soil with (r= -0.684, p> 0.001). Among the remaining factors a positive significant relationship was found among organic matter and nitrogen contents of the soil (r=0.854, P> 0.001). Similarly organic matter were also found in significant relationship with potassium (r= 0.397, p>0.05) as shown in the table (3). The results also show that there is a significant relationship between nitrogen and potassium (r= 0.456, p> 0.01) as well potassium and phosphorus (r= 0.673, p> 0.001). Clay particles are found in negative significant relations with sand (r= -0.673, p> 0.001) and in positive significant relation with silt contents of the soil (r= 631, p> 0.001).

**Table 3.** Cross correlation among environmental variables

| | El | Sl | As | Whc/10gm | pH | %OM | %Lime | N (g kg-1) | P (mg kg-1) | K (mg kg-1) | Sa% | Cl % | Si % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E | 1 | | | | | | | | | | | | |
| Sl | -0.226 | 1 | | | | | | | | | | | |
| As | 0.234 | -0.039 | 1 | | | | | | | | | | |
| Whc/10gm | 0.077 | -0.048 | 0.12 | 1 | | | | | | | | | |
| Ph | 0.425* | -0.031 | 0.27 | 0.126 | 1 | | | | | | | | |
| %OM | 0.06 | -0.047 | -0.177 | 0.221 | 0.057 | 1 | | | | | | | |
| %Li | 0.236 | 0.121 | 0.358 | -0.168 | 0.513** | -0.015 | 1 | | | | | | |
| N (g kg-1) | 0.013 | -0.183 | -0.129 | 0.269 | 0.063 | 0.854*** | -0.076 | 1 | | | | | |
| P (mg kg-1) | 0.599*** | -0.408* | -0.269 | 0.083 | 0.052 | 0.195 | -0.207 | 0.249 | 1 | | | | |
| K (mg kg-1) | 0.394* | -0.544** | -0.196 | 0.036 | 0.182 | 0.397* | -0.108 | 0.456** | 0.734*** | 1 | | | |
| Sa % | -0.175 | 0.145 | -0.165 | 0.208 | -0.31 | -0.246 | -0.684*** | -0.192 | -0.06 | -0.144 | 1 | | |
| Cl % | 0.182 | -0.256 | 0.465** | -0.154 | 0.418** | 0.029 | 0.640*** | 0.043 | -0.084 | 0.2 | -0.673*** | 1 | |
| Si% | 0.517** | -0.252 | 0.367 | -0.003 | 0.553** | 0.243 | 0.641*** | 0.291 | 0.269 | 0.359 | -0.811 | 0.631*** | 1 |

Key: El=Elevation, Sl=Slope, As= Aspect, Whc/10g=water hc/10gm, pH. % OM=Organic matter, % Li=%Lime, N(g kg-1)=Tot. N (g kg-1), Phosphors=P (mg kg-1), K (mg kg-1), =Potassium(mg kg-1), Sa= Sand %, Cl=Clay %, Si=Silt %.

*Non-Metric Multidimensional Scaling (NMS ordination)*

NMS ordination plot shows the distribution of *Dodonaea viscosa* dominated vegetation communities. Based on mean importance values of species the groups derived through cluster analysis (CA) are also superimposed on the axis of NMS plot (Axis 1, 2) shows an almost clock wise rotation between the two axis. Group I is present in the middle of NMS plot. In this group the ivi of *Dodonaea* is third highest and elevation mean value of the group is second highest. Group II which is present at low altitude is positioned at the right side and in the bottom towards axis 1.Group III is present in the extreme left side of NMS plot toward axis 2. The elevation mean value of this group is second highest. Group IV is present in the extreme upper part between the two axis of NMS plot (Fig: 3). The elevation mean value of group IV is greater than group II while smaller than the elevation of all other groups. The stands of Group V are present in the extreme right side of axis 1.

*Correlation of Environmental variables with NMS ordination axis*

Table (4) represents the co-relations of different environmental variables with the ordination axis 1 and axis 2 of NMS plot. Among the studied 13 environmental factors only one factor (% Clay particles) showed significant relationship with the NMS ordination axis 1 (r= 0.494, p-value > 0.01), while axis 2 showed significant relationship with slope r=0.457 p> 0.01), Potassium (r=0.346, p>0.01), clay particles (r=.0.494, p> 0.01). There is not found any significant relationship of the remaining factors with the NMS ordination axis 1 and axis 2.

*DCA ordination*

In DCA ordination the communities are isolated from each other and the rotation of vegetation communities groups is clock wise between axis 1 and axis 2. The vegetation community of group I is present in the center of DCA ordination plot between axis 1 and axis 2. Group II is located in the extreme left side overlapping towards axis 2. Group III is located in the upper part toward axis 2 while, group IV is situated in the extreme right side of ordination (DCA) toward axis 2, 1.

The vegetation communities of group V are located in the bottom of DCA ordination plot in the right side. The rotation of *Dodonaea* dominated communities along ordination axis 1.2 and 2, 3 shows an overlapping between some sampling sites in the vegetation groups derived through Ward's cluster analysis. In the DCA ordination plot between axis 1 and axis 3 some stands of community group I are overlapped with group III. Group I is situated in the center, group II is located in the extreme left side, while groups III, V are located in the upper portion in the left side of the ordination axis 1, 3. Vegetation communities of group IV are located in the extreme right side of DCA Ordination plot. The ordination of different groups is irregular between axis 1,3,2,3.

The DCA plot between axis 2,3 shows that the sampling stands of group V is located in the upper portion towards left side while group III is present in the extreme right side, these two groups are isolated while the remaining three groups which overlapping each other are present in the middle of DCA ordination axis 2 and axis 3.

This ordination of vegetation communities is due to the correlation of environmental variables which are found in significant relationship with DCA ordination axis.

*Correlation of environmental variables along with DCA ordination axis*

The correlation of DCA ordination axis with environmental showed that among 13 studied parameters only slope angle of the site (0.394p>0.05, soil pH (r= 0.540 p>p>0.01) and organic matter (r= 0.382 p>p>0.05) were found in significant relationship with DCA ordination axis 1. Similarly DCA ordination axis 2 was correlated significantly with soil water holding capacity (r= 0.495 p>0.01), organic matter (r= 0.472 p> 0.05), and nitrogen contents of the soil (r=0.415 p> 0.05).

The results also show that DCA ordination axis 3 is not significantly correlated with any one of the factors of the sampling stands.

As it is clear from the results that the distribution of vegetation communities is due to those parameters which are significantly correlated with ordination axis while, the other factors are moving along (Fig.3).

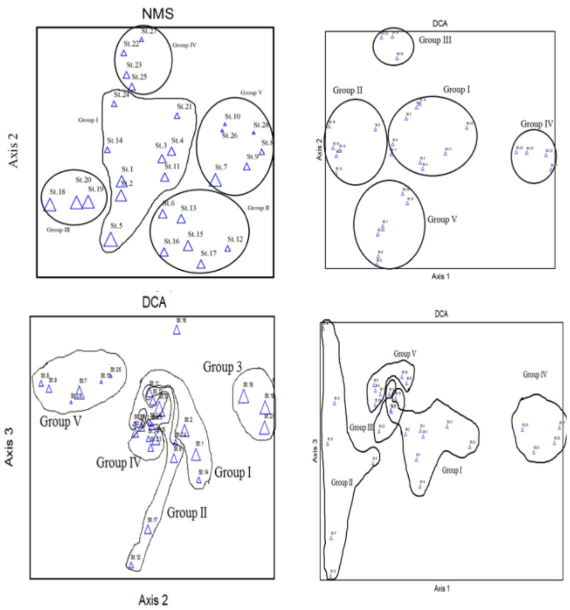


**Fig. 3.** Correlation of environmental variables along with DCA ordination axis

**Table 4.** Correlation of NMS and DCA ordination axis with environmental variables.

| | NMS ordination | | | | DCA ordination | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Correlation** | **Axis I** | | **Axis 2** | | **Axis 1** | | **Axis 2** | | **Axis 3** | |
| E. Factors | R value | Remarks | R value | Remarks | R value | Remarks | R value | Remarks | R value | Remarks |
| Elevation | 0.132 | | 0.231 | Non sig | 0.138 | | 0.18 | | 0.22 | |
| Slope | 0.217 | | 0.457 | Sig | 0.394 | Sig(p>0.05) | 0.351 | | 0.226 | |
| Aspect | 0.193 | | 0.23 | | 0.103 | | 0.007 | | 0.242 | |
| water hc/10gm | 0.286 | | 0.327 | | 0.202 | | 0.495 | Sig (p>0.01) | 0.022 | |
| pH | 0.026 | | 0.365 | | 0.54 | Sig (p>0.01) | 0.063 | | 0.353 | |
| %OM | 0.088 | | 0.365 | | 0.382 | Sig(p>0.05) | 0.472 | Sig(p>0.05) | 0.153 | |
| %Lime | 0.234 | | 0.239 | | 0.172 | | 0.036 | | 0.022 | |
| Tot.N (g kg-1) | 0.083 | | 0.133 | | 0.321 | | 0.415 | Sig(p>0.05) | 0.008 | |
| P (mg kg-1) | 0.088 | | 0.2 | | 0.068 | | 0.203 | | 0.221 | |
| K (mg kg-1) | 0.079 | | 0.346 | Sig | 0.414 | | 0.118 | | 0.051 | |
| Sand % | 0.286 | | 0.117 | | 0.164 | | 0.176 | | 0.1 | |
| Clay % | 0.494 | Sig | 0.343 | Sig | 0.305 | | 0.065 | | 0.265 | |
| Silt% | 0.203 | | 0.264 | | 0.348 | | 0.084 | | 0.242 | |

*Density/ha*

Density/ha mean values of *Dodonaea viscose* along with associated vegetation are summarized in table (5). In group I the density of the dominant species *Dodonaea* viscosa is 928.67±128.96 mean individuals/ha. The co-dominant species in term of density /ha is *I. gerardiana* (404.42±77.55) followed by *P. rugosus* (204.98±29.85) and *Gymnosporia* (186.32±61.14). Among the other species of community group I the mean density/ha of *Olea cuspidate* is 141.71±34.77, *C. microphyllum* 126.34±46.23, *J. adhatoda*80.97±37.86, *D. mucronata* 80.34±35.71, *O. limbata* 72.67±44.08 *M.philiphinsis* 64.68±44.05, *A. modesta* 63.04±33.81 and *B. lycium*is 46.03±24.63 individuals/ha. The mean density /ha of the remaining species such as *F. carica* is 34.51±27.04 *C. astralis* (26.77±26.77) *E. lanceolatus* (12.80±8.21) and *Myrsine Africana* 12.38±12.38 individuals. In terms of density/ha *C. microphylus, V. negundo, P .aphylla, M. africana*and *A. scoparia* are the remaining rare species of group I. The mean density/ha of these species is given in table (3.6). Among the 18 species of group II the dominant species is *D. viscose* with mean density/ha 864.85±60.61 followed by *O. limbata* (363. 89±50. 32), *I. gerardiana* (231.39±91.51), *C. microphyllum* (192.43±40.97), *B. lyceum* (168.85±26.85) and *E. lanceolatus* (138.96±35.48). *C. astralis, J. adhatoda, Gymnosporia, V. negundo, F. carica, O. cuspidate, A. gracilis, P. aphylla, P. rugosus, D. mucronata* and *A. scoparia* are other species in association with *Dodonaea* community.

Their mean density/ha ranged from (96.92±46.65 to 11.11±11.11)/ha. Based on number of species, community group III is the smallest community comprised of six species in which *D. viscosa* is the dominant species with 1524. 39±26.46 mean density/ha. The density/ha of *Dodonaea* is more in community III as compared to all other communities. *A. modesta* is the co-dominant species sharing 256.12±59.34 mean density. Among the remaining four species of this community, the mean density/ha of *P. rugosus* is 233.66±62.76, *I. gerardiana* 219.02±109.61, *B. lycium*193.60±5.52and *Q. dilatata*is 73.22±12.46/ha. In group IV the leading dominant species is *Dodonaea* viscosa with 605.10±95.64 mean density /ha. As it is clear from the results that the mean density/ha values of community group IV and Group V is low as compared to other communities. The density of the dominant species is same in community IV and V. In terms of mean density/ha the co-dominant species of community IV is *A. altissima* sharing 312.92±53.17 mean density. Among the remaining eight species community IV the mean density/ha of *X. stramarium* is 295.06±90.04 followed by *J. adhatoda* (277.76±44. 43), *O. cuspidate* (224.47±64.09), *P. rugosus* (222. 03±37.32), D. *mucronata* (214.61±39.31) and *M. philiphinsis* (201.73±8.72) (Table 5). The mean density/ha of the remaining two species is 88.95±40.16, 57.39±22.74. Out of six stands and 10 species of community V the mean density/ha of the leading dominant species, *D. viscosa* is same as in community group V.

The co-dominant species in association with *D. viscosa* is *Gymnosporia* with 469.97±84.28 density/ha. Among the remaining species of group V the mean density/ha of *O. limbata* is 395.38±37.48, *J. adhatoda* 300.08±26.59. *P. rugosus* 225.34±49.41, *R. fruticosus*186.85±87.72 and *I. gerardiana* is 101.33±50.0. *A. modesta, O. cuspidate*, *E. lanceolatus* are the remaining rarely present species of community V. *Cover /ha* The detail of cover/ha of *D. viscosa* associated species is summarized below. In group I the cover/ha of *D. viscosa*is 1195.24±111.01cm.

The results shows that cover /ha of *Dodonaea* in group I is more than all other communities. In terms of cover/ha the co-dominant species is *I. gerardiana* (241.87±40. 74cm/ha followed by *O. cuspidate, Gymnosporia, C. microphyllum, P. rugosus*. The mean cover/ha of these species ranged from 127.74 to 182.46 while. The cover/ha mean values of the remaining species such as *J. adhatoda, M. philiphinsis, M. africana, D. mucronata, A. modesta, C. microphylus, B. lycium, F. carica, V.negundo, C. astralis, E. lanceolatus, O. limbata, P. aphylla* and *A. scoparia ranged from* 0.11±0.11cm/ha to 97.50±41. 98cm/ha.

The mean cover/ha of *D. viscosa* in group II is 1182.75±59.67cm which is less than group I but more than all other communities. In group III it is 1034.68±43.22cm/ha while in group IV and V the mean cover/ha is (906.75±153.34, 662±296.45) cm which is less cower/ha values as compared to other communities (Table 3.8).

The co-dominant species in community I is *I.gerardiana* in community II *O.limbata* while in group III, IV and V the co-dominant species are *I.gerardiana*, *A. altissima*and *P. rugosus* with mean values of cover/ha (241.87±40.74, 186.94±24.67, 410.55±205.28, 268.68±78.06, 545±170.56)cm respectively as summarized in table (5). The cover/ha mean of the remaining species is given in table (5).

**Table 5.** Mean Values Density/ha and Cover/ha of Species in different Communities

| | Density/ha | | | | | Cover/ha | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Species | Group I | Group II | Group III | Group IV | Group V | Group I | Group II | Group III | Group IV | Group V |
| Code | Mean±SE | Mean±SE | Mean±SE | Mean±SE | Mean±SE | Mean±SE | Mean±SE | Mean±SE | Mean±SE | Mean±SE |
| Dv | 928.67±128.96 | 864.85±60.61 | 1524.39±26.46 | 605.10±95.64 | 605.57±105.95 | 1195.24±111.01 | 1182.75±59.67 | 1034.68±43.22 | 906.75±153.34 | 662±296.45 |
| Bl | 46.03±24.63 | 168.85±26.85 | 193.60±5.52 | - | - | 36.80±22.04 | 152.43±27.92 | 262.66±32.44 | - | - |
| Ig | 404.42±77.55 | 231.39±91.51 | 219.02±109.61 | 88.95±40.16 | 101.33±50.01 | 241.87±40.74 | 181.75±82.87 | 410.55±205.28 | 63.42±32.81 | 83±37.32 |
| Oc | 141.71±34.77 | 47.76±27.95 | - | 224.47±64.09 | 85.15±38.53 | 182.46±51.10 | 55.67±34.96 | - | 152.19±34.44 | 72±33.06 |
| Pr | 204.98±29.85 | 14.37±14.37 | 233.66±62.76 | 222.03±37.32 | 225.34±49.41 | 127.74±29.48 | 7.30±7.30 | 334.87±79.09 | 139.38±32.14 | 545±170.56 |
| Cm | 126.34±46.23 | 192.43±40.97 | - | - | - | 144.17±53.81 | 160.79±36.51 | - | - | - |
| Dm | 80.34±35.71 | 23.55±16.67 | - | 214.61±39.31 | - | 55.70±24.28 | 16.39±10.48 | - | 249.56±86.38 | - |
| Gy | 186.32±61.14 | 76.39±42.29 | - | - | 469.97±84.28 | 171.19±52.94 | 52.59±29.26 | - | - | 251±57.02 |
| Pp | 2.22±2.22 | - | - | - | 0 | 1.57±1.57 | - | - | - | - |
| OL | 72.67±44.08 | 363.89±50.32 | - | - | 395.38±37.48 | 10.96±5.28 | 186.94±24.67 | - | - | 207±66.17 |
| Ja | 80.97±37.86 | 78.49±16.87 | - | 277.76±44.43 | 300.08±26.59 | 97.50±41.98 | 84.11±18.09 | - | 202.36±34.02 | 413±110.48 |
| As | 1.48±1.48 | 11.11±11.11 | - | - | - | 0.11±0.11 | 5.67±5.67 | - | - | - |
| Mm | 5.56±5.56 | - | - | - | - | 4.02±4.02 | - | - | - | - |
| El | 12.80±8.21 | 138.96±35.48 | - | - | 57.26±26.54 | 19.70±15.51 | 150.53±34.54 | - | - | 124±59.20 |
| Rf | - | - | - | - | 186.85±87.72 | - | - | - | - | 103±52.34 |
| Am | 63.04±33.81 | - | 256.12±59.34 | - | 73.08±38.53 | 51.16±30.87 | - | 275.52±79.65 | - | 40±19.57 |
| Ca | 26.77±26.77 | 96.92±46.65 | - | - | - | 19.85±19.85 | 91.60±42.28 | - | - | - |
| Vn | 4.13±4.13 | 73.83±36.46 | - | - | - | 3.85±3.85 | 97.57±48.24 | - | - | - |
| Fc | 34.51±27.04 | 5.97±5.97 | - | 57.39±22.74 | - | 34.78±27.07 | 5.40±5.40 | - | 94.19±45.86 | - |
| Ag | - | 46.74±36.98 | - | - | - | - | 30.16±25.53 | - | - | - |
| Ma | 12.38±12.38 | - | - | - | - | 9.69±9.69 | - | - | - | - |
| Plac | - | 25.66±23.90 | - | - | - | - | 10.98±10.09 | - | - | - |
| Qd | - | - | 73.22±12.46 | - | - | - | - | 181.72±60.91 | - | - |
| Mp | 64.68±44.05 | - | - | 201.73±8.72 | - | 91.71±64.10 | - | - | 213.92±66.21 | - |
| Aa | - | - | - | 312.92±53.17 | - | - | - | - | 268.68±78.06 | - |
| Xs | - | - | - | 295.06±90.04 | - | - | - | - | 209.55±53.25 | - |

*Height and Cover size classes of Dodonaea viscosa*

Fig.s (4) represent the group's density/ha of *D. viscosa* in different size classes. The frequency of classes shows that more number of individuals fall in lower size classes while, the frequency of individuals in upper size classes is low as well as there is found a gap in the height classes such as in group I, II and IV. The result also shows that the maximum height of *D. viscosa* is found in the range of 411-450 in group V. In all the communities' groups the frequency of 3rd class is high as compared to other. In the communities groups the variable number of individuals in different height classes of *Dodonaea* represents multimodal shapes. Communities Group 1, III and V represent reverse J-shaped or *L-shaped* structures. The results shows that in all these three groups there is found a gap in the height size classes, which may be due to the anthropogenic disturbance which was observed during the field survey of different sampling sites. The remaining two groups (II, IV) of the *D. viscosa* dominated vegetation represent almost bell-shaped structure. In these groups there is not found any gape in the height size classes though the highest number of individuals fall in the middle classes. Ought of nine classes of group II, only three percent individuals/ha of *Dodonaea* attained 331-370cm height. The maximum heights of *Dodonaea viscosa* in community Group V was found in the range of 411-450cm and 0.4% individuals/ha was found in this class.

The structure of cover size classes of Dodonaea in Communities' groups I, 2 and 3representing bell-shape structure. Out of the four classes of group III the maximum cover/ha is found in 2nd class (51%) In group IV, the maximum cower is found in 3rd class. The results indicate that the cover /ha was high in upper three classes. As indicated in the Fig.s the polynomial curve of community group III and IV represent a unique pattern due to the large difference in the middle and lower size classes. These two communities' groups (III, IV) representing un-evenshaped structure.

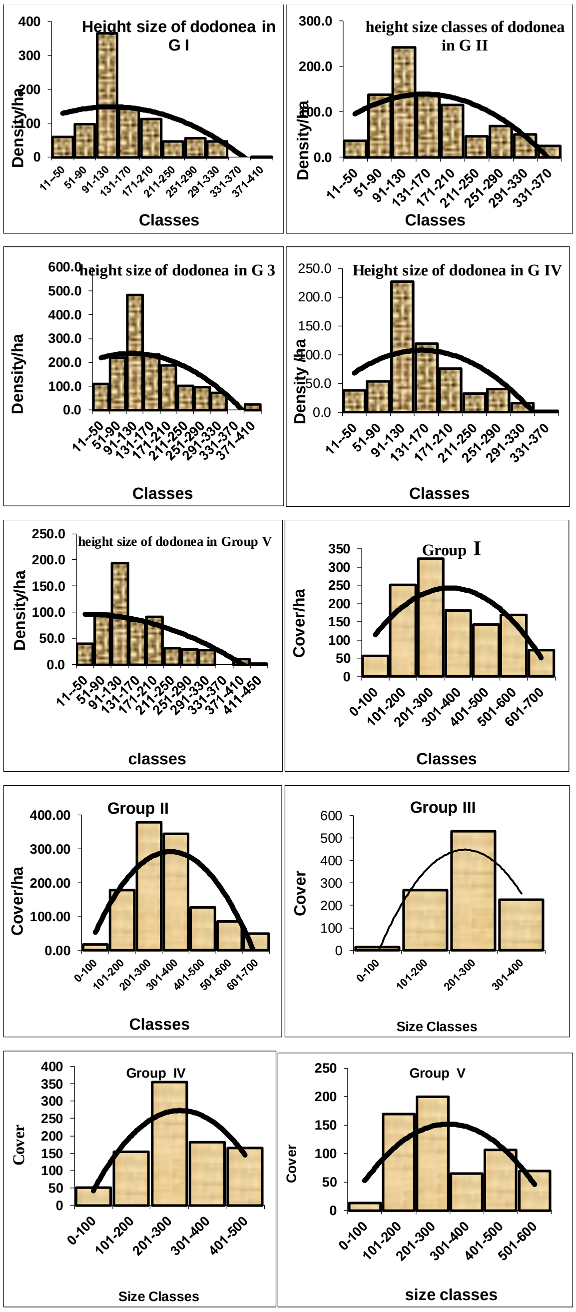


**Fig. 4.** Height and Cover size classes of *Dodonaea viscosa*

## Discussion

Based on classification Ward's cluster analysis *Dodonaea viscosa* dominated area of Malakand division was classified into five distinct plants communities. All the communities were dominated by *Dodonaea viscosa* while, the co-dominant species were different in different communities. The co-dominant species of community I, II were *I. gerardiana*, in community III *B. lyceum*, in community IV *A. altissima* while in community V the co-dominant species was *Gymnosporia*. A total of 27 plants species are recorded in twenty-eight sampling sites belong to twenty one families and twenty six genera. Out of twenty-one families only six families (Asclepidaceae, Asteraceae, Lamiaceae, Oleaceae, Papilonaceae and family Rosaceae) shared two (for each) species. The remaining thirteen families are monospecific. Except family Asclepidaceae all the remaining families are represented by a single genus. Shariatullah (2013) reported 34 species while sampling *J. adhatoda* communities in Malakand division. Rahman (2013) reported 73 species belong to 34 families while studying *S. brevifolium* communities in Dir Lower. The ivi mean values of 28 stands and 27species found in the Dodonaea *viscosa* dominated communities was subjected to multi-variate analysis (Ward's cluster analysis). The vegetation data was separated into five distinct plants communities such as *Dodonaea-indegopera* Comm-unity (I), *Dodonaea-Indegopera* Community (II), *Dodonaea-Berberis* Community (III), *Dodonaea-Aillanthus* Community IV, *Dodonaea-Gymnosporia* Community (V). Similar study was conducted by Ahmad *et al.* (2011) for the communities' description of Deodar forest in Himalayan range of Pakistan and reported seven plants communities. Kavgaci *et al.* (2013)applied classification and ordination techni-ques and reported four plants communities of *Pinusnigra* dominated forests in Turkey. Rahman (2013) reported six plants communities while stud-ying the phytosociology of *S. brevifolium*. Khan *et al.* (2011) reported five plants communities while study-ing the regeneration and structure of *Monotheca buxifolia* in district Dir lower. Some species such as *I. gerardiana, O. cuspidate, P. rugosus* and *Gymno-sporia are* mostly repeated with *D.viscosa*in the sampling sites, the reason may be the same environmental condition and nutritional need as reported by the other authors (Ahmed *et al.* 2009; Shariatullah 2013; Khan and Bibi 2013). Some species such as *A. gracilis, P. rugosus, Q. dilatata, P. aphylla, A. scoparia, C. microphylus, M. africana, P. aphylla, A. gracilis, P. rugosus, A. altissima* and *X. stramarium* are rarely found in the communities of *D. viscosa*. These species may be loss in the future if proper care was not taken (Rahman 2013) because, these species are locally used by the inhabitant of the area for different purposes such as medicine fuels, shelters and fodders (khan *et al.* 2011).

In term of species composition, Community I is the richest as compared to other communities in which the IVI mean value of *D. viscosa* is high as compared to other communities. This community is situated at high altitude but, low than Group III. Slope angle is steep for all communities except group IV which is situated at Moderate slope (Khan *et al.* 2013). Beside the co-dominant species (*I. gerardiana),*some other important species of community I are, *Gymnosporia, P. rugosus D. mucronata, J. adhatoda, M. philiphinsis, A.modesta, O. cuspidate, B. lyceum O.limbata*, *V. negundo* and *C. astralisetc.* Beside these *M. africana, C. microphyllum, F. carica* and *P. phyla* were only found in group I. Community II is the second richest in term of species. In this community the ivi of dominant species *D. viscosa* was greater than all other communities except community III (45%), but altitude was low (461m) as compared to other groups. The co dominant species in this community was also *I. gerardiana* but difference was found in the IVI mean value. The dominant species of community III is *D. viscosa* while the co-dominant species is *B. lyceum*. Theivi mean value of *D. viscosa* in this group was the largest as compared to other groups. It is because *D.viscosa* establish community best in the areas where other vegetation is disturbed. Our finding is strongly supported by Bekele (2000) who reported that *Dodonaea* colonize barren areas. *P. rugosus, A. modesta, I. gerardiana* and *Q.dilatata* are found in association with the dominant species. Group IV comprised of 10 species in which *D. viscosa*is dominant while the co-dominant species is *A. altissima*. The other species of this group are *J. adhatoda*, *D. mucronata*, *O. cuspidate*, *M. philiphinsis*, *P. rugosus*, *F. carica*, *I. gerardiana* and *X. stramarium*. *A. altissima* and *X. stramarium* are the species which are only found in group IV.

Group V is also dominated by *D. viscosa* but the ivi mean value of *Dodonaea* viscosa is low as compared to other groups. In group V *Gymnosporia* is the co-dominant species while other species which are found in association with Dodonaea are *P. rugosus*, *J. adhatoda*, *O. limbata*, *R. fruticosus, I. gerardiana*, *E. lanceolatus, O. cuspidate* and *A. modesta*. The difference in the species composition and ivi of Dodonaea is because of the environmental variables and soil constituents in which difference is found in different communities. Much has been discussed about the relationship of species richness with environmental variables and soil properties of the area (Schuster and Diekmann 2005; Stevens 1992; Khan *et al*. 2011; Khan *et al*. 2013). The inter correlation was performed among different parameters in order to know about their relationship. A strong positive significant relationship of elevation was found with soil pH phosphorus, potassium and silt particles of the sampling stands. There is a negative significant relationship between slope angle with phosphorus, potassium while, positive significant relationship with clay particles. pH was found in significant relationship with lime content, clay % and silt % of the soil. Organic matter was found in significant relation with nitrogen potassium, nitrogen and potassium, potassium and phosphorus, lime content with silt, while negative relation was found between lime and sand particle as well as between sand and clay particles of the soil. Similar study was conducted by Khan (2012) and reported positive significant relation between altitude and potassium, slope and aspect, potassium and sodium, water holding capacity with nitrogen. There was not found any significant relation of organic matter with all the studied 15 parameters. Zhang and Zhang (2011) reported positive significant relation of soil organic matter with elevation, Nitrogen, phosphorus, and reported that the degradation of organic matter, as both Nitrogen and phosphorus comes from the same source (organic matter) because organic matter is the most important variable in the soil (Tang and Ohsawa 1999) while the role of aspect is not clear on the nutrient of soil but affect the pattern of vegetation communities.

The groups derived through Wards cluster analysis were also superimposed on the ordination plots. Greig-Smith (1983) reported that cluster analysis and ordination are complimentary to each other though fundamentally used for different purposes. In the present study Clay particles showed significant relationship with the NMS ordination axis 1. Axis 2 of showed strongly significant correlation with slope, Potassium and clay particles. Khan, (2012) argued that the soil moisture, soil nutrients, rainfall, past disturbances, mass effects and chance factor are responsible for the distribution of forest communities. In the present study slope angle of the site, pH and organic matter were found in significant relationship with DCA ordination axis 1, axis 2 was correlated significantly with three environmental factors such as soil water holding capacity, organic matter and nitrogen contents of the soil. Khan *et al* (2011) reported positive significant relationship of Ordination axis with elevation, salinity, conductivity, Na, Nitrogen and soil. Our result is in correlation with Gauch and Whittaker (1981), and McCune and Mefford (2005) who stated that DCA is only capable of yielding one basic gradient associated with the vegetation. The results showed that the distribution of vegetation communities is due to those parameters which are significantly correlated with ordination axis while, the other factors moving along.

A large difference is observed among the density and cover/ha of *D. viscosa* and other associated species. The difference is because of the variation in the values of environmental variables which were found in significant correlation with DCA and NMS ordination axes. The highest density/ha of *D. viscosa* was recorded in community group III as this community is situated at high altitude, high slope angle, organic matter, water holding capacity clay %, and Nitrogen content in the soil were high as compared to other communities while potassium content were medium in soil and the soil was acidic in nature. Our finding shows that the distribution of *D. viscosa* and associated plants species is controlled by the above mentioned parameters which are found in significant correlation with the DCA and NMS ordination axes.

Similar study was conducted by Ahmed *et al.* (2009) and stated that the density decrease with increase in elevation. Ahmad *et al.* (2006) reported that density of vegetation depend upon environmental factors and found the highest stand density at northern facing aspect in *Cedrus* dominated forests. Similarly Khan *et al.* (2013) and Titshall *et al.* (2000) reported that slope and altitude are the main environmental variables which control the distribution of vegetation density. Our finding is in correlation with Rahman (2013) reported that beside altitude aspect also play important roles in the distribution of vegetation communities. El-Sheikh and Yousef (1981) reported that soil moisture play a key role in the in the distribution of plants communities. Tavili and Jafari (2009) reported that nutrient status, EC, soil texture, slope and aspect are the most important factors that correlated strongly with the distribution of ecological communities. Our results is also strongly supported by Zare *et al.* (2011) who described the importance of slope, aspect elevation, soil texture, available nitrogen, potassium, organic matter, lime and soil moisture in the distributionof the vegetation. In community III only five species were found in association with *Dodonaea viscosa* which shows that the density of the target species increase when other vegetations are degraded.

The results of soil analysis also shows that *D. viscosa* mostly grows in calcareous soils as about 95% communities of *D. viscosa* belong to calcareous soils with a texture Loamy Sand to sandy loam with low phosphorus and marginal nitrogen and potassium contents. All the *D. viscosa* communities are reported from rocky soil and windy areas. Our results are also supported by Edward and Gilman (1999) who reported that *D. viscosa* tolerates sandy or rocky soils and drought conditions. The communities were reported from any aspect which shows that *D. viscosa* can grows at any aspect but it favors sun facing slope.
The height and cover sized classed showed a multi-model pattern such as reverse J- shaped, L-shaped, Bell-shaped almost bell shaped and Un-even pattern. The reverse J-shaped and L-shaped represent that more individuals are present in lower sized classes while the bell-shaped and almost Bell-shaped indicating the high density in upper sized classes. The high density in lower classes is due to two reason (i) the communities are recently introduced to the area or (ii)strong regeneration potential of Dodonaea while the high density in middle sized classes shows bell shaped pattern which is due to the weak regeneration or anthropogenic disturbance due to which less number of individuals remains to produced seeds as the people cutting the plants for different purposes. The un-even pattern is because of the anthropogenic disturbance as observed during field survive. Similar study was conducted by (Rahman 2013) and reported irregular, almost bell-shaped and bell-shapedpattern. The high density in the lower classes is because of strong regeneration potential of the species while (Shariatullah 2013) reported that less density in the higher classes may be the growth rate as the seedling and juvenile plants grow more rapidly as compared to mature plants (Hitimana *et al.* 2004). The pattern in the size classes can be modified due to anthropogenic activities, inter-specific and intra-specific competition and pattern of regeneration (Faridah-hanum *et al.* 2012). The density in different size classes tells us about the resource utilization of site bythe species. There were also found some gapes in sized classes of Dodonaea viscosa which is because of the over exploitation as reported by (Shariatullah 2013; Rahman 2013).

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