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Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2020 17(2):1082-1094. **OPEN ACCESS**

An ecological assessment of *Justicia adhatoda* L. in Malakand Division, Hindukush range of Pakistan

Shariat Ullah[*1], Nasrullah Khan[1], Fayaz Ali[2], Lal Badshah[3], Asghar Ali[4] and Noor Muhammad[5]

[1]Department of Botany, University of Malakand, Chakdara 18800, Dir lower, **Pakistan**
[2]Shaheed Benazir Bhutto University Sheringal, Dir upper 890118, **Pakistan**
[3]Department of Botany, University of Peshawar 25000, **Pakistan**
[4]Government AKL, Post Graduate College Matta, Swat 19130, **Pakistan**
[5]College of Horticultural, Hebei Agricultural University, Baoding, Hebei 071001, **China**

***Correspondence:** shariatullahuom@gmail.com **Received 14-05-2020, Revised: 06-06-2020, Accepted: 08-06-2020 e-Published: 10-06-2020**

Plants have played a critical role in maintaining human health and improving the quality of human life for thousands of years. *Justiciaadhatoda* is frequently distributed in protected and open areas in the lesser hill slopes of Malakand division. Numerous reports from Pakistan and abroad have established the medicinal importance of *Justiciaadhatoda*. However, little is known about the community structure, pattern, and regeneration dynamics processes of the species in Pakistan. This study was designed to understand the vegetation-environment interplay and species diversity in *Justiciaadhatoda* dominated communities in the foothills of Malakand division. Twenty plots of 10m × 10m (100m^2) were sampled at the individual stand. Cluster Analysis (Wards agglomerative Techniques) classified 34 species and 30 sample plots into six groups dominated by *Justiciaadhatoda* while *Xanthium strumamium*, *Morus alba*, *Calotropisprocera*, *Vitexnegundo*, *Dodonaeaviscosa,* and *Meliaazedarach*were the co-dominant species. DCA-ordination has revealed elevation, nitrogen and organic matter to be the key factors, significantly influencing the species composition and distribution pattern of *Justicia adhatoda* dominated vegetation in the region. All the vegetation types had an average low value of Shannon's species richness, diversity index, and Evenness index (J') per plot. The density and cover ha^{-1} of the dominant and associated plant species were calculated. Cover classes showed breaks in the lesser size classes due to the human interferences and other natural processes. However, it was concluded that anthropogenic activities are the significant aspects accountable for the degradation of these vegetation types in the study area.
Keywords: Classification, DCA- ordination, environmental factors, anthropogenic activities.

INTRODUCTION

Phytosociology helps in understanding the interaction of plant communities with their environment (El-Bana and Al-Mathnani, 2009, Barton, 1993) which alters along with the environmental factors (McCune and Grace, 2002). However, changes in plant communities and richness are mainly due to different factors at an area and landscape-level (Eilu et al., 2004) which includes climate factors, physiography, and soil mainly for scattering outlines (Ringrose et al., 2003, Shaltout et al., 1995, McAuliffe 1994). Some of the ecologists reported human activities and natural disasters as key factors in effecting the distribution and function of plants (Timilsina et al., 2009). The expected position of spatial factors, biotic connections, and ecological stochasticity must be counted also for the attention of communication of plant communities with environmental factors (Song et al.,. 2009).

The Subtropical dry temperate forests of Hindukush range are considered to be areas with rich plant diversity, because of the variation in environmental degrees (Stewart, 1982) these are taken as biodiversity hotspots. The eastern Hindukush range vegetation exposes the major patches of deteriorating annual precipitation from southeast to northwest with reasonable features of elevation zonation in flora crossing more than 4,000m a.s.l. (above sea level) (Nusser and Dickore, 2002). However, Hindukush range forests of Malakand division area awkwardly in tension mainly due to natural and man made turbulences, including security situations (Khan et al., 2015, Khan et al., 2013). Agricultural expansion, population explosion, and infrastructure development have also resulted in major destruction of natural environments that has led to a major decline in the productive and protective forests in different elevational straps and sub-regions (Khan et al., 2011). Muslim graveyards are considered protected areas and in this part of the world, post-military operation, the degraded or threatened vegetation types can be compared with the graveyards to measure the extant of vegetation loss in the area (Molnar et al., 2017, Champion et al., 1965). Besides the huge anthropogenic disturbances, these graveyards are still considered as best sites for research as they are least disturbed areas (Loki et al., 2015). A review of the literature revealed that some studies (Kreutz and Colak, 2009, Kreutz, 1998) elaborated this angle in Muslim countries where distributions of plants in the graveyard-vegetation have been explored. A study in the 300 Muslim graveyards of Turkey from 30 provinces reported 86 taxa which are almost half of the known Turkish orchid flora. (Molnar et al., 2017) conducted similar work in Albanian graveyards by studying 166 different Muslim graveyards. Medicinal plants of the graveyards were also studied by some ecologists (Hadi et al., 2014, Rahman et al., 2008, Dafni, 2006). A literature review shows that very few ecologists have tried to study the vegetation pattern of graveyards concerning the phytosociological aspects (Ahmad et al., 2010, Ahmed et al., 2009, Chaghtai et al., 1983, Niazi, 1975).

These were mainly floristic studies and little or no importance was given to the phytosociological details of these vegetation types found in Muslim graveyards. Graveyard vegetation is naturally protected because of religious belief and significant changes in the parent material of soil, as the decay of human bodies constantly increases the fertility of the soil in these microhabitats (Chaghtai et al., 1978). Therefore, it was of utmost importance to highlight the effect of environmental factors on the vegetation pattern of these graveyards which are thought to be good for the study of natural vegetation. Therefore, a detailed study was conducted with the objectives, i. to document plant communities and, ii. to highlight the influence of environmental factors which help in the distribution of plant species. The findings of the current work will help frame conservation strategies and management of these micro-ecosystems in the Malakand division of northern Pakistan.

MATERIALS AND METHODS

Study site

Malakand division is situated in lower ranges of Hindukush, Pakistan, and located between latitude 35°30 N and 72° 00 E longitude at an altitude between 700-7000m a.s.l (above sea level) (Khan, 2011).The area is spread over 952 km^2. For the present study, areas with thick vegetation of *Justicia adhatoda* at lower elevation were selected for sampling. Rough terrain, heaving valleys, average to sharp slopes, hills, huge peaks, plains, and certain water tributaries linking to main channels are the key structures of the study area (Hazrat et al., 2008). District Lower Dir and Upper Dir are located adjacent to District Chitral (Fig. 1). Both districts are very diverse in terms of vegetation comprising of conifers, broad-leaved trees, shrubs, and herbs (Wahab, 2011). On lower elevations beneath the pine zone, thick vegetation of *Dodonaea viscosa* in association with *Indigofera gerardiana*, *Otostegia limbata*, *Plectranthus rugosus*, *Periploca aphylla*, *Micromeria biflora*, *Myrtus communis* and *Buddleja crispa,* etc. was found (Yousifzai et al., 2012). All the sample plots were situated on flat (5°) to moderate slope (28°). The climate of the area is roughly continental having hot summer with a temperature ranging from 15.67°C to 32.52 °C. Winters are harsh with a temperature range of -2.39°C to 11.22°C. Temperatures usually fall below freezing points at higher elevations. Rainfall is recorded with high variation all the year ranging from 410 to 1334.3 mm. May to July was observed as dry periods having 5.13mm while August to October was observed as rainy months 56.62mm (Ali et al., 2017).

Sampling design and data collection

Upon investigation of the study area, it was found that the forest dominated by *Justicia* was

Figure 1:Detail map of the study area representing major districts i.e. Swat, Dir Lower, Dir (Upper) and Buner

fragmented into 3 forest patches *i.e.* Graveyards, Open fields and Hill slopes.

Following the protocols of (Ryniker et al., 2006) least disturbed natural forest, spread on at least 1 hectors were selected for sampling in the area during 2018 and 2019. Descriptive information like elevation, geographical coordinates, slope and aspect was recorded. The aspect was classified into eight classes (i.e. N, NE, E, SE, S, SW, W, and NW) and recorded for each sampling site following (Khan et al., 2012).

A total of ten quadrates (sample plots) of 10 × 10m= 100m^2 at regular intervals were taken following the method of (Cox, 1980). An equal number of sub-samples (2 × 2m) were used inside the main sample plots to collect data on small seedlings and juveniles of the dominant shrubs. In each sample plot number of plants, clump cover, and height of the dominant shrub were measured as advised by many ecologists (Zhang and Zhang, 2007, Parker et al., 2004). To assess the community development of *Justicia adhatoda* and sub-ordinate species seedlings of each species (of height less than 10cm) were recorded. Associated herbs and shrubs species were also noted along with their ecological features as interactive species in the sampling sites. Such information of admixed species is important because, these co-species compete with the dominated species (*Justicia*) for available nutrients, water, moisture, etc. (Speer, 2010, Cook, 2003, Fritts, 1976). Soil samples were collected by adopting standard procedures as suggested by (Khan et al., 2011, Siddiqui, 2011).

Data analysis

The collected data was organized and used for the analysis of phytosociological attributes like frequency, relative frequency (F_3), density, relative density (D_3), cover, relative cover (C_3), and importance values (IVI). Evenness of the individual species was obtained and the average values were computed in the analysis. Among the different phytosociological attributes and absolute values, importance value index was preferred for the classification and ordination of vegetation. Importance value index was computed from relative dominance (relative basal area) and relative density (Song et al., 2009, Baruch, 2005).

Various clustering producers are used by various workers. However, Ward's agglomerative cluster analysis (CA) was applied in the current study on two data sets, each of thirty stands. Plant species having a contribution of 4% or more were considered in the analysis. DCA was first used to highlight the outliers to exclude them in the analysis for smooth and good results to examine shapes of vegetation types and link the structure with environmental factors respectively using PC-ORD software (McCune and Mefford, 1999).

Environmental variables used in classification and ordination were checked within the Cluster Analysis (CA). Elevation, Slope angle, and aspect were the three parameters used as variables in the cluster analysis. The slope was divided into four different categories including gentle, moderate, steep, and very steep. The aspect was classified into eight groups and was studied as North=1, West=2, South=3, and East= 4, NE=5, SE=6, SW=7, NW=8, for quantitative statistical analysis (Palmer, 2005). Analysis of variance (ANOVA) was used for the evaluation of variations between the groups.

RESULTS

Species composition and diversity

The shrubby and woody tree species recorded in the current work were identified and presented in (Table. 1; Fig. 2) shows the occurrence of all the species in all forest stands studied. The study area was dominated by *Justicia adhatoda* of the family Acanthaceae, the Sapindaceae family (*Dodonaea viscosa*), Asteraceae family (*Xanthium strumarium*) and Mimosaceae family (*Acacia modesta*). Other species belonged to Moraceae (*Morus alba*, *Ficus palmata*), Verbenaceae (*Vitex negundo*) and Meliaceae family (*Melia azedarach*). However, the members of Sapotaceae (*Monotheca buxifolia*), Rosaceae (*Ziziphus nummularia*), and Pinaceae (*Pinus roxburghii*) were rarely distributed in association with the dominant species.

There were 23 species in group 1 and the average species richness was 7.1 (± 0.59 SD) per plot (Shannon's species richness index, H'), and the average species richness was 0.59 (± 0.30 SD) per plot (Shannon's Evenness index, J'). The value for Evenness (E) was 0.567 while the diversity (Shannon`s diversity index, H) was 1.205 (Table. 1). In addition, the value for Simpson`s diversity index was 0.1487 for the overall sample plot and species. *Justicia adhatoda*, *Xanthium strumarium*, *Morus alba*, *Dodonaea viscosa*, *Acacia modesta* and *Vitex negundo* were found to be the most dominant species in the forest.

Cluster analysis (CA) of stands

Cluster Dendrogram using Ward's agglomerative technique (Fig. 2) was applied for the classification of 34 plant species distributed in 30 sampled sites. As a result, six different vegetation types were obtained with 75% information in the abundance of species retained. Four groups were extracted as major whereas, two groups were clustered as isolated groups. The detailed description of the groups is given below.

Group-I *Justicia-Xanthium*

Group 1 consisting of 5 stands, and 23 species. This group was predominately composed of *Justicia adhatoda* (I.V. 30±2.6%) and *Xanthium strumarium* with 15% importance value. *Artemisia maritima*, *Dodonaea viscosa*, *Vitex negundo* and *Morus alba* were subordinate species in the shrubby stratum with mean importance value ranging from 3 to 11%. Among other species, *Dalbergia sissoo* (4.6%), *Zanthoxylum armatum* (3.6%) *Melia azedarach* (3%), and *Ziziphus* (3%) were sparsely distributed while the remaining species were scarce having frequency ranged from 0.4% to 2.6%.

Sampling sites of this group were located on an average elevation of 868±116m above sea level (a.s.l), which was the third-highest of all the groups, whereas the average slope was 8° and generally North facing. Clay and Silt contents were lowest (13±1.4; 37±3.9) while the proportion of sand particles was highest (48±4.3) in the soil for this group (Table. 3). The soil organic matter was ranked second among all the groups.

Group-II *Justicia-Morus*

Group II comprised of seven stands and 22 species which were also dominated by *Justicia adhatoda* (IVI= 30±0.6%) while *Artemisia maritima* were co-dominant species with a mean importance value of 10±2.8%. *Dalbergia sissoo* (8±1.9), *Eucalyptus camaldulensis* (7.8±2.3), *Calotropis procera* (6±1.6), *Vitex negundo* (4.4±4.5%),*Olea ferruginea* (3±1.4%) and *Ricinus communis* (3±1.5%) were subordinate species with comparatively low importance values. Among the other species *Melia azedarach*, *Ziziphus jujuba*, *Populus nigra* and *Ailanthus altissima* were observed with low importance value ranging from

0.4 to 1.7%. The rest of the species were occasional with extremely low importance values (Table. 2). The results of the environmental variable are presented in (Table. 3).

Group-III *Justicia-Dodonaea*

Group III consisted of eight stands and 17 species. This group was the largest in terms of stands and dominated by *Justicia adhatoda* with an average importance value of 26±1.4%. *Dodonaea viscosa* was the co-dominant species with an average importance value of 19±2.3% while *Meliaa zedarach*, *Ailanthus altissima*, *Eucalyptus camaldulensis,* and *Calotropis procera* were subordinate species with 9±1.1, 8±1.4, 5±1.8 and 3.6±1.2% of importance values respectively. Other species associated with this group were *Ficus palmata*, *Olea ferruginea*, *Populus nigra* and *Xanthium strumarium* showed low abundance in this group (Table. 2). In addition, *Pinus roxburghii* contributed only 1±1% importance value among the species associated in this group.

Stands of this group were situated at the third-lowest elevation (average of 752±33.6m) with a gentle slope (10°) facing mostly North and East aspects. The soil of the group was slightly alkaline (7.6± 0.06) while the organic matter in the soil was moderately low.

Group-IV *Justicia-Vitex*

This group was an outlier and represented by a single stand and 9 species (Fig. 2). The maximum importance value was recorded for *Justicia adhatoda* (81±3.8) and *Vitex negundo* (3.5±2.5%) in this group. Among other species, *Ziziphus* and *Olea ferruginea* were the sub-ordinate species with mean importance values of 3±2.6% and 2±1.4% respectively. However, *Melia azedarach*, *Dodonaea viscosa*, *Ficus palmata* and *Morus alba* showed very low importance values (Table. 2).

Sampling sites of this vegetation type was located on the highest average elevation (894±45.4m), among all groups with gentle (11°)slope (Table. 2). Soil organic matter was recorded as the second-highest among all the groups. The texture of the soil was sandy as sand content was 41±3.2% while the clay was only 15±0.8% in this group. Lime% was highest, while nitrogen content was second-highest among all groups and similar to group I.

Group-V *Justicia-Dodonaea*

Group V comprised of eight sampling sites having 6 different species (Table. 2). *Justicia adhatoda* was recorded as the dominant species with 52±8.1% of importance value. *Dodonaea viscose* was recorded as co-dominant species with an average of 38±8.1% importance value. *Monothec abuxifolia* and *Artemisia maritima* had low importance values in this group. *Ziziphus jujuba* and *Morus nigra* were among the other species that contributed an average of 0.5 to 1% importance values.

Stands of this group were located on an average elevation of 888±8.1m a.s.l, with a comparatively gentle 8° slope (Table. 3). The texture of soil was predominantly composed of sand (44±8.1) and silt (41±8.1%) respectively. However, clay content was comparatively low and was similar to that of groups 2 and 3 (Table. 3). Phosphorus and Potassium levels were high, while the value of nitrogen was lowest among all groups. Extremely low concentration (1±8.1%) of organic matter was recorded while soil pH was alkaline for this group.

Group-VI *Justicia-Melia*

Similar to group IV, group VI was also composed of one vegetation standand dominated by *Justicia adhatoda*, *Mellia azedarach* and *Broussonetia papyrifera* (Table. 2). *Justicia adhatoda* was ranked as the leading species with 59±8.1% of importance value, whereas, *Melia azedarach* and *Broussonetia papyrifera* occurred with low importance value (3±8.1%). This group showed extremely poor floristic composition among all the groups.

All the sampling sites in this vegetation type were at low elevations (670±8.1m) and gentle slope (9°).The stands were facing West aspects and were of a higher order. The value of soil organic matter was highest among all groups. The soil had 55% of sand and 19% of silt particles, whereas, the clay content was almost negligible (Table 3). The value of lime was similar to that of group 3 while nitrogen was highest among all groups. In addition, Phosphorus and Potassium levels were highest and soil reaction was slightly alkaline (Table. 3)

Univariate analysis of variance (ANOVA)

Six main groups and two isolated stands were obtained from Ward's agglomerative techniques using the importance value index of the plant species. Edaphic and topographic variables were analyzed among the resulted six groups using univariate analysis of variance (ANOVA),to compare meansand the results are presented in (Table. 4).

Table 1: Summary of the diversity and evenness of 34 Species and 30 stands.

Name	Mean	Stand. Dev.	Sum	Minimum	Maximum	S	E	H	D`
Ja	44.967	24.460	1349.0	21.000	100.00	30	0.962	3.271	0.9571
Gn	0.667	3.651	20.00	0.000	20.000	1	0.000	0.000	0.0000
Xs	3.167	6.534	95.00	0.000	23.000	7	0.948	1.845	0.8295
Mn	0.300	1.643	9.00	0.000	9.000	1	0.000	0.000	0.0000
Is	0.167	0.913	5.00	0.000	5.000	1	0.000	0.000	0.0000
Ma	4.133	5.544	124.00	0.000	23.000	16	0.930	2.579	0.9087
Fc	1.633	2.697	49.00	0.000	12.000	12	0.928	2.305	0.8788
Vn	1.100	3.898	33.00	0.000	20.000	4	0.747	1.035	0.5620
Caa	0.667	2.073	20.00	0.000	8.000	3	0.984	1.081	0.6550
Ge	0.067	0.365	2.000	0.000	2.000	1	0.000	0.000	0.0000
Gt	0.100	0.548	3.00	0.000	3.000	1	0.000	0.000	0.0000
Xa	0.633	1.829	19.00	0.000	9.000	5	0.865	1.393	0.6981
Ds	4.067	4.863	122.00	0.000	16.000	15	0.962	2.606	0.9206
Am	7.067	7.759	212.00	0.000	22.000	19	0.932	2.745	0.9278
Cp	2.467	3.683	74.00	0.000	12.000	13	0.931	2.388	0.8948
Dv	8.400	10.278	252.00	0.000	38.000	20	0.904	2.707	0.9184
Rc	1.000	2.464	30.00	0.000	10.000	5	0.958	1.542	0.7711
Me	3.800	4.205	114.00	0.000	14.000	18	0.948	2.740	0.9272
Ob	0.167	0.648	5.00	0.000	3.000	2	0.971	0.673	0.4800
Zj	2.767	4.083	83.00	0.000	19.000	170.903	2.5	60	0.8965
Pn	0.633	1.691	19.00	0.000	8.000	50.9	17	1.476	0.7368
Aa	3.133	4.049	94.00	0.000	15.000	160.93	4	2.589	0.9129
Eh	0.200	1.095	6.000	0.000	6.000	1	0.000	0.000	0.0000
Of	1.733	3.311	52.00	0.000	10.000	70.98	5	1.916	0.8491
Za	0.067	0.365	2.000	0.000	2.000	10.000	0.000	0.0000	
To	0.100	0.548	3.000	0.000	3.000	10.000	0.000	0.0000	
Eu	3.667	5.182	110.00	0.000	14.000	120.962	2.389	0.9023	
Pg	0.133	0.571	4.000	0.000	3.000	20.811	0.562	0.3750	
Cam	0.100	0.548	3.000	0.000	3.000	10.000	0.000	0.0000	
Pr	1.067	4.571	32.00	0.000	24.000	20.811	0.562	0.3750	
Mb	0.200	1.095	6.000	0.000	6.000	10.000	0.000	0.0000	
Bp	1.267	6.938	38.00	0.000	38.000	10.000	0.000	0.0000	
Jb	0.267	1.461	8.000	0.000	8.000	10.000	0.000	0.0000	
Mr	0.100	0.548	3.00	0.000	3.000	10.000	0.000	0.0000	
AVG:	2.941	3.650	88.24	0.6176	15.03	7.1	0.567	1.205	0.4817

Ja= *Justicia adhatoda*, Xs= *Xanthium strumarium*, Is=*Iris spuria,* Ma=*Morus alba,* Fc= *Ficus palmata,* Vn= *Vitex negundo,* Caa= *Calendula arvensis,* Gr= *Grewia asiatica,* Ds= *Dalbergia sissoo,* Am= *Acacia modesta,* Cp= *Calotropis procera,* Dv= *Dodonaea viscosa,* Rc= *Ricinus communis,* Me= *Melia azedarach,* Ob= *Ocilicum bacillus,* Zj= *Ziziphus jujuba,* Pn= *Populus nigra,* Aa= *Ailanthus altissima,* Of= *Olea ferruginea,* Za= *Zanthoxylum armatum,* To= *Taraxacum officinale,* Eu, *Eucalyptus camaldulensis,* Pg= *Punica granatum,* Cam= *Chenopodium ambrosioides,* Pr= *Pinus roxburghii,* Mb= *Monotheca buxifolia,* Bp= *Broussonetia papyrifera,* Jujuba= *Ziziphus mauritiana,* Mr= *Morus nigra*

Table 2: Mean Importance value for different groups obtained from Ward's cluster analysis using 34 species and 30 sample plots.

Species	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE
Ja	32±2.6	30±0.6	26±1.4	81±3.8	52±8.1	59±8.1
Gn	4±4	0±0	0±0	0±0	0±0	0±0
Xs	15±3.0	1.4±1.4	1±1	0±0	0±0	0±0
Pp	1.8±1.8	0±0	0±0	0±0	0±0	0±0
Is	1±1	0±0	0±0	0±0	0±0	0±0
Mal	3±1.15	10±2.8	3.5±1	1.5±1.5	0±0	0±0
Fc	2±0.6	3±1.7	2±0.7	0.3±0.3	0±0	0±0
Vn	4.4±4.4	4.4±4.5	0±0	3.5±2.5	0±0	0±0
Car	2.6±1.6	1±1	0±0	0±0	0±0	0±0
Ge	0.4±0.4	0±0	0±0	0±0	0±0	0±0
Gt	0.5±0.5	0±0	0±0	0±0	0±0	0±0
Za	3.6±1.8	0.8±0.5	0.25±0.25	0±0	0±0	0±0
Ds	4.6±1.9	8±1.9	5±1.7	0±0	0±0	0±0
Am	11±4.8	10±2.5	8±3.0	2±1.0	4±8.1	0±0
Cp	0.25±0.25	6±1.6	3.6±1.2	0±0	0±0	0±0
Dv	6±1.5	4±0.9	19±2.4	0.5±0.5	38±8.1	0±0
Rc	1±1	3±1.5	0.5±0.5	0±0	0±0	0±0
Me	3±1.2	1.7±0.6	9±1.1	2±1.3	0±0	3±8.1
Ob	0±0	0.7±0.4	0±0	0±0	0±0	0±0
Zj	3±1.0	3±0.7	2±0.5	3±2.6	0±0	0±0
Pn	0±0	1.5±1.1	1±0.5	0±0	0±0	0±0
Aal	2.4±0.8	1.5±1.1	8±1.4	0±0	0±0	0±0
Nas	0±0	0.8±0.8	0±0	0±0	0±0	0±0
Of	0±0	3±1.4	1.1±1.1	2±1.4	0±0	0±0
Ote	0±0	0.2±0.2	0±0	0±0	0±0	0±0
To	0±0	0.4±0.4	0±0	0±0	0±0	0±0
Eu	3±1.4	7.8±2.3	5±1.8	0±0	0±0	0±0
Pg	0.6±0.6	0±0	0±0	0±0	0±0	0±0
Cam	0.6±0.6	0±0	0±0	0±0	0±0	0±0
Pinus	0±0	0±0	1±1	0±0	0±0	0±0
Mono	0±0	0±0	0±0	0±0	6±8.1	0±0
Bro	0±0	0±0	0±0	0±0	0±0	3±8.1
Ziz	0±0	0±0	0±0	0±0	1±1	0±0
Mn	0±0	0±0	0±0	0±0	0.5±0.5	0±0

Ja= *Justicia adhatoda,* Xs= *Xanthium strumarium,* Is=*Iris spuria,* Mal= *Morus alba,* Fc= *Ficus palmata,* Vn= *Vitex negundo,* Car= *Calendula arvensis,* Gr= *Grewia asiatica,* Xa= *Zanthopxylum armatum,* Ds= *Dalbergia sissoo,* Am= *Acacia modesta,* Cp= *Calotropis procera,* Dv= *Dodonaea viscosa,* Rc= *Ricinus communis,* Me= *Melia azedarach,* Ob= *Ocimum basilicum,* Zy= *Ziziphus jujuba,* Pn= *Populus nigra,* Aal= *Ailanthus altissima,* Of= *Olea ferruginea,* To= *Taraxacum officinale,* Eu, *Eucalyptus camaldulensis,* Np= *Punica granatum,* Cam= *Chenopodium ambrosioides, Pinus= Pinus roxburghii,* Mono= *Monotheca buxifolia,* Bro= *Broussonetia papyrifera, Jujuba= Ziziphus mauritiana,* Mn= *Morus nigra*

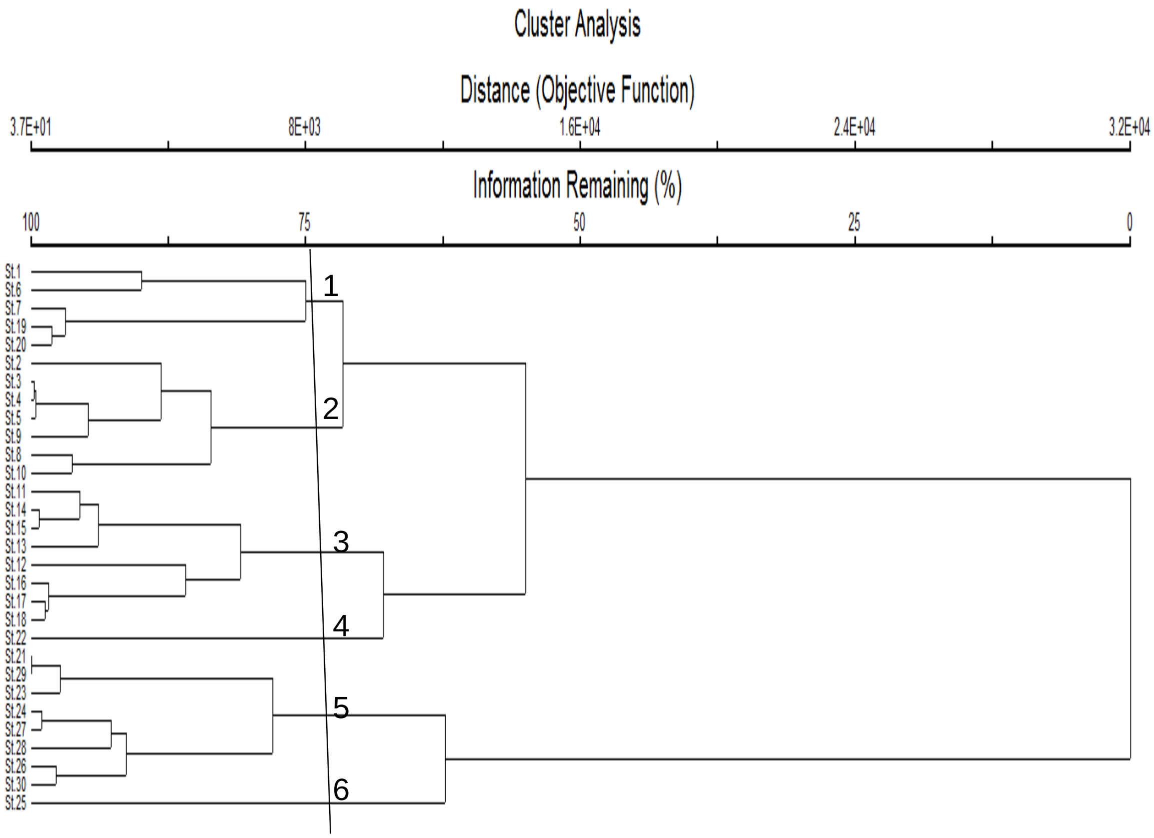

Figure 2: Cluster analysis of sampling stands (30 stands) indicating six groups. In terms of community clustering group, 3 is the most distinct group representing 8 stands followed by group 2 and 5. Groups 4 and 6 are isolated individuals.

Table 3:Mean values of environmental factors for six groups obtained from cluster analysis.

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE
Elevation	868±116.7	663±75.3	752±33.6	894±45.5	888±8.1	670±8.1
Slope	8±2.9	11±1.7	10±1.8	11±1.2	8±8.1	9±8.1
Aspect	1.4±0.2	2±0.2	1.8±0.2	3.3±0.3	4±8.1	4±8.1
Clay	13±1.4	14±1.1	14±0.8	15±0.8	14±8.1	19±8.1
Silt	37±3.9	47±3.2	46±2.8	41±3.6	41±8.1	55±8.1
Sand	48±4.3	38±3.9	38±2.9	41±3.2	44±8.1	25±8.1
PH	7.5±0.04	7.4±0.1	7.6±0.06	7.6±0.06	7.7±8.1	7.5±8.1
Org. Matter	2.7±0.6	2.1±0.5	1.6±0.6	2.6±0.7	1±8.1	2.9±8.1
Lime (%)	14±1.4	15±2.7	13±1.3	16±4.4	10±8.1	13±8.1
N(%)	0.13±0.03	0.10±0.02	0.08±0.03	0.13±0.03	0.05±8.1	0.14±8.1
P (mg/Kg)	6.7±0.4	7.3±0.56	6.7±0.3	6.7±0.3	7.1±8.1	8±8.1
K (mg/Kg)	82±18.6	82±9.8	100±13.9	85±18.6	94±8.4	112±8.1

Table 4: Analysis of variance (ANOVA) among various environmental and soil factors.

	Source of variation	SS	Df	MS	F	P-Value
Elevation	Between Groups	512522.6	6	85420.43	2.454	
	Within Groups	1350387	23	58712.49		Sig
	Total	1862910	29			
Slope	Between Groups	1422.26	6	237.04	2.868	
	Within Groups	1900.93	23	82.64		P<.05
	Total	3323.2	29			
Aspect	Between Groups	18.1428	6	3.0238	0.4442	
	Within Groups	156.55	23	6.8068		Ns
	Total	174.7	29			
O. matter (%)	Between Groups	17.9989	6	2.9998	1.175	
	Within Groups	58.7162	23	2.5528		Ns
	Total	76.7151	29			
Silt (%)	Between Groups	2.206	6	0.36766		
	Within Groups	2.379	23	0.10347	3.5531	Ns
	Total	4.5859	29			
K (%)	Between Groups	2.7709	6	0.4618	1.2966	
	Within Groups	8.1915	23	0.3561		Ns
	Total	10.962	29			
N (%)	Between Groups	4.3078	6	0.7179		
	Within Groups	1.447	23	0.062	11.409	P<.001
	Total		29			
pH	Between Groups	0.8787	6	0.1464	0.7571	
	Within Groups	4.449	23	0.1934		Ns
	Total	5.327	29			
Clay (%)	Between Groups	474.29	6	79.048	0.8527	
	Within Groups	2132.17	23	92.703		Ns
	Total	2606.46	29			
Sand (%)	Between Groups	0.02885	6	0.00481		
	Within Groups	0.26081	23	0.01134	0.42413	Ns
	Total	0.28966	29			

SS= sum of square, df= degree of freedom, MS=mean of square F= F value, P-Value Ns= not significant

Table 5: Pearson Product Movement Correlation Coefficients (PPMCC) among the edaphic and topographic variables and DCA ordination axes 1, 2, and 3.

	Axis 1		Axis 2		Axis 3	
Variables	r-value	P-value	r-value	P-value	r-value	P-value
Elevation	0.2999	p>0.02	0.2105	Ns	0.3235	p>0.02
Slope	0.0032	Ns	0.0556	Ns	0.0545	Ns
Aspect	0.0405	Ns	0.2616	p>0.02	0.1087	Ns
N%	0.3146	p>0.02	0.1661	Ns	0.3589	p>0.05
P (mg/kg)	0.0627	Ns	0.2198	Ns	0.1908	Ns
K (mg/kg)	0.0541	Ns	0.0253	Ns	0.1068	Ns
Clay (%)	0.2078	Ns	0.0737	Ns	0.0588	Ns
Silt (%)	0.179	Ns	0.2077	Ns	0.2499	p>0.02
Sand (%)	0.1095	Ns	0.1759	Ns	0.2535	p>0.02
pH	0.0389	Ns	0.0002	Ns	0.1717	Ns
Organic matter (%)	0.3165	p>0.02	0.1657	Ns	0.3558	p>0.05
Lime (%)	0.0096	Ns	0.0684	Ns	0.2362	Ns

Ns= Non-significant

Among the topographic variables, elevation and aspect were found to be significant (F =2.065; P<0.10 and F =2.573; P<0.05) respectively, while slope showed no significant difference among the six groups.

Water holding capacity, soil pH, sand, clay, and silt were found to be non-significant. However, lime showed a significant difference (F =2.612; P<0.01) at the given probability level. In addition, potassium and phosphorus also showed non-significant relationships.

Correlation between DCA-ordination and environmental variables

The correlation among the environmental factors and DCA ordination axes 1, 2, and 3 is presented in (Table. 5). Pearson Product Movement Correlation Coefficients (PPMCC) were used for the degree of strength between theordination axis and environmental variables. The results revealed that elevation, nitrogen (%), and organic matter had a weak positive relationship ($p>0.02$) with axis 1, whereas, the DCA ordination axis 2 show a weak correlation with the aspect of the sampled plots.

The correlation of environmental variables and axis 3 indicated somewhat more significant relationships with several variables (Table. 5). Elevation, sand, and silt were significantly correlated with the ordination axis 3 ($p>0.02$) while, nitrogen (%) and organic matter showed a strong relationship ($p>0.05$) as compared to these variables. Among other soil variables, pH, lime (%), phosphorus, and potassium contents did not give a good connection with any of the ordination axis.

DISCUSSION

Multivariate techniques like classification and ordination were found handy in the exposition of the basic group structure and the principle environmental variables affecting the distribution of these community types. The Ward's agglomerative techniques resulted in the formation of six vegetation types that dominated *Justicia adhatoda* were connected to different edaphic, topographic, and soil variables. The percentage chaining in cluster analysis (CA) was not very large compared to sites in large areas with a low distance between transects. The sample plots were mostly less than one ha and were fragmented. Researchers have suggested a large scale forested area for gradient analysis (El-Ghani and Amer, 2003, Sagers and Lyon, 1997, Whittaker, 1970). In the present study although the groups obtained are not distinct at small scale but still there are apparent groupings, which can be used in addressing the management of the *Justicia adhatoda* and associated vegetation. For instance, species like *Xanthium strumarium*, *Calotropis procera* and *Pinus roxburghii* were exotic, deserted, and retreating to a higher elevation where they could not escape the pressure from residents on the other side of the open and protected areas.

Moreover, species like *Monotheca buxifolia* and *Morus alba* were highly preferred by local people for a specific purpose like fruits and fuel wood extraction. The local inhabitants collected fruits of both the species in summer, eaten fresh or dried, and even sold in the local market (Khan et al., 2011). Similarly, *Ficus palmata* is also an associated species with *Justicia adhatoda* whose fruit is of value due to its medicinal importance but it is very scarce in the forests. *Dodonaea viscose* was recorded as leading species based on the importance value index in open and hilly areas on lower elevation of the study area. This species is strongly associated with the dominant species and in the future, the dominance of this species will undoubtedly alter the overall ecological matrix and functions of the *Justicia* dominated forest. *Olea ferruginea* is an important evergreen woody species of the locality (Ahmed et al., 2009). They discussed the importance and threats to the species in detail. In the current study, it was noticed that *Olea ferruginea* was less abundant in terms of its importance value and density. It is also a preferred host for *Viscum album*, which a common partial parasite in the study area, and a threat to the dispersion of *Olea ferruginea* species. On the other hand, the problem of governance of some exotic and unwanted species that is the risk for the flora and especially to *Justicia adhatoda* and they can be discouraged by introducing native plant species in these habitats (Siddiqui et al., 2013, Khan et al., 2010).

In the current study, the species richness and diversity were found much lesser in comparison to other vegetation types. This may be attributed to a small area as several workers reported that diversity naturally tends to increase with increasing sampling area (Betru et al., 2005, McGarigal and Marks, 1997). The species diversity at protected and open areas in *Justicia adhatoda* dominated forest was substantial, 34 species in 30 sample plots (one or ½ hectare total area). However, the forest area was dominated by slow-growing halophytes and upper canopy trees such as *Olea ferruginea*, *Ficus palmata*, *Monotheca buxifolia* and *Acacia modesta*. These tree species are immensely threatened due to over-exploitation for fuelwood and this in turn is a threat to the forest ecosystem of the study area.

Different ordination techniques were applied to make sure a clear pre-dominant environmental gradient responsible for the vegetation distribution. The present information regarding the sample plots and species ordination method was useful because the community data matrices had to fulfill some properties such as dominating and sparse species, frequent and infrequent species as well as factors influencing the dispersion of these species in the study area (Palmer, 2005, McCune and Grace, 2002). The data and results of the present study obey the rules to the supposition of multivariate procedure except for the necessities for cautious interpretation of the result because of the small area considered in the present investigation.The ordination results revealed that several topographic and soil variables like elevation, nitrogen (%), and organic matter are collectively responsible for the distribution pattern of *Justicia adhatoda* dominated vegetation in the study area. It would be sufficient to say that the presence of contradictory interest in the forest will at least prolong the period of destruction of the forest which will give a breathing space for intervention i.e. properly charted conservation strategies. The value of the forest should be seen not only from the monitory point but from the very existence of two immediate beneficiaries. The forest college located in Dir upper is entirely dependent on the forest for research purposes to continue as a viable forestry college, while the local inhabitants heavily depend on the timber and fuelwood collection. Hence, in addressing the problems faced by these forest species especially the medicinal plants, it is important to conserve and protect these vegetation types in the larger interest of the environment itself and different stakeholders.

CONCLUSION

We concluded from the results that *Justicia adhatoda* dominated vegetation is severely disturbed due to anthropogenic pressure yet topographic and soil variables like elevation, nitrogen (%), and organic matter are predominately responsible for shaping the population structure and its current distribution pattern in the region. These factors must be considered in the conversation plans in the larger interest of the environment and different stakeholders.

CONFLICT OF INTEREST

The authors declared that present study was performed in the absence of any conflict of interest.

ACKNOWLEDGMENT

Authors are highly thankful to Prof. ® Mehboob-ur-Rehman who identified the plants collected during this study with authority.

AUTHOR CONTRIBUTIONS

SU and NKplanned the study and experimental designs for vegetation sampling and also wrote the manuscript. FA and NM helped in the field sampling and data analysis. AA and LB help out in the interpretation of the results and reviewed the manuscript. All authors read and approved the final version.

REFERENCES

Ahmad, S., Khan, N., Wahab, M and Nazim, K. 2010. Vegetation studies of selected graveyards of upper Swat. International journal of Biology and Biotechnology (Pakistan). 7: 211-217.

Ahmed, M., Khan, N., Wahab, M., Hamza, S., Siddiqui, M. F., Nazim, K and Khan, M. U. 2009. Vegetation structure of *Olea ferruginea* (Royle) forest of Dir Lower District of Pakistan.Pakistan Journal Botany. 41 (6): 2683-2683.

Ali, F., Khan, N., Ali, K and Khan, I. 2017. Influence of environmental variables on the distribution of woody species in Muslim Graveyards of Malakand Division, Hindukush Range Mountain, Pakistan. Pakistan Journal of Botany. 49 (6): 2357-2366.

Barthorp, M. 1986. War on the Nile: Britain, Egypt and the Sudan. 1882-1898. Sterling Publishing, USA.

Barton, A. M. 1993. Factors controlling plant distributions: drought, competition and fire in montane pines in Arizona. Ecological Monographs. 63 (4): 367–397.

Baruch, Z. 2005. Vegetation-environment relationships and classification of the seasonal savannas in Venezuela. Flora. 200 (1): 49-64.

Betru, N., Ali, J and Nyborg, I. 2005. Exploring ecological and socio-economic issues for the improvement of area enclosure management a case Study from Ethiopia. DCG report No. 38. pp.3-30

Chaghtai, S. M., Rana, N. A and Khattak, H. R. 1983.Phytosociology of Muslim graveyards of Kohat Division, N.W.F.P. Pakistan Journal of Botany. 15 (2): 99-108.

Chaghtai, S. M., Shah, S. H and Akhtar, M. A. 1978.Phytosociological study of the graveyards of Peshawar district, Pakistan.Pakistan Journal of Botany. 10 (1): 17-30.

Champion, H. G., Seth, S. K and Khattak, G. M. 1965. Forest Types of Pakistan. Pakistan Forest Institute, Peshawar.

Cook, E. R., Krusic, P. J and Jones, P. D. 2003. Dendroclimatic signals in long tree-ring chronologies from the Himalayas of Nepal. International Journal of Climatology.23: 707-732.

Cox, G. W. 1980. Laboratory manual of general ecology. William C. Brown Company, Dubuque, IA.

Dafni, A., Lev, E., Beckmann, S and Eichberger, C. 2006. Ritual plants of Muslim graveyards in northern Israel. Journal of Ethnobiology and Ethnomedicine.2 (38): 1-12.

Eilu, G., Hafashimana, D. L.N and Kasenene, J. M. H. 2004. Density and species diversity of trees in four tropical forests of the Albertine rift, western Uganda. Diversity and Distribution. 10 (4): 303-312.

El-Bana M. I and Al-Mathnani, A. S. 2009. Vegetation-soil relationships in the Wadi Al-Hayat Area of Libyan Sahara.Australian Journal of Basic and Applied Sciences. 3 (2): 740−747.

El-Ghani, M. A. A and Amer, W. M. 2003. Soil-vegetation relationships in a coastal desert plain of southern Sinai, Egypt.Journal of Arid Environments. 55 (7): 607-628.

Fritts, H.C. 1976. Tree-Ring and Climate. Blackburn Press, Caldwell, New Jersey.

Hadi, F., Ibrar, M and Zaidi, N. 2014.Role of Dag Behsud graveyard in conservation of indigenous medicinal flora of district Nowshera, Pakistan.Scholarly Journal of Agriculture Science. 4 (2)**:** 87–89.

Hazrat, A., Shah, J and Khan, A. J. 2008.Medicinal value of family Ranunculaceae of Dir district. Pakistan Journal of Botany. 39 (4): 1037-1044.

Khan, A. A., Ali, F., Ihsan, M., Hayat, K and Nabi, G. 2015.Ethnobotanical study of the Medicinal Plants of Tehsil Charbagh, District Swat, Khyber Pakhtunkhwa, Pakistan.American-Eurasian Journal of Agriculture and Environmental Sciences. 15 (7): 1464-1474.

Khan, N. 2011.Vegetation ecology and dendrochronology of Chitral.Ph.D thesis FUUAST, Pakistan.

Khan, N. 2012. A community analysis of *Quercus baloot* Griff forest District Dir upper, Pakistan.African journal of Plant Science. 5 (12): 21-31.

Khan, N., Ahmed, M., Wahab, M and Ajaib, M. 2010.Phytosociology, structure and Physiochemical analysis of soil in *Quercus baloot* Griff, District Chitral Pakistan.Pakistan Journal of Botany. 42 (4): 2429-2441.

Khan, N., Ahmed.M., Shaukat, S. S., Wahab, M and Siddiqui, M. F. 2011.Structure, diversity and regeneration potential of *Monothe caboxifolia* (Falc.) A. DC. Dominated forests of Lower Dir District, Pakistan.Frontier of agriculture in China. 5: 106-121.

Khan, N., Shaukat, S. S., Ahmed, M and Siddiqui, M. F. 2013. Vegetation-environment relationships in the forests of Chitral district Hindukush range of Pakistan. Journal of Forestry Research. 24 (2): 205−216.

Khan, S.M., Harper, D., Page, S and Ahmed, H. 2011. Species and community diversity of vascular flora along environmental gradient in Naran Valley: A multivariate approach through indicator species analysis. Pakistan Journal of Botany. 43 (5): 2337−2346.

Kreutz, C. A. J and Çolak, A. H. 2009. TürkiyeOrkideleri. Istanbul: Rota Yayınları.

Kreutz, C. A. J. 1998. Die Orchideen der Türkei. Landgraaf: Kreutz&Seckel.

Loki, V., Jácint, T., Kristóf, S., Ádám, L. K., Kaan, H., Gábor, S and Attila, M.V. 2015. The orchid flora of Turkish graveyards: a comprehensive field survey. Willdenowia. 45 (2): 231-243.

McAuliffe, J. R. 1994. Landscape evolution, soil formation, and ecological patterns and processes in Sonoran Desert bajadas.Ecological Monographs. 64: 111–148.

McCune, B and Grace, J. B. 2002.Analysis of Ecological Communities.MjM Software Design, Gleneden Beach, Oregon, USA.

McCune, B and Mefford, M. J. 1999.Multivariate Analysis of Ecological Data.Version 4.01 MjM Software, Gleneden Beach, Oregon, USA.

McGarigal, K and Marks, B. 1997. FRAGSTATS: Spatial Pattern Analysis Program for Quantifying Landscape Structure. USDA Forest Service - General Technical Report PNW-GTR-351.

Molnar, A. M., Attila, T., Edvard, M., Viktor, L., Zoltan, B., Gabor, S and Jacint, T. 2017. Religious differences affect orchid diversity of Albanian graveyards. Pakistan Joiurnal of Botany. 49 (1): 289-303.

Niazi, D. M. K. 1975. Graveyard flora of Bannu and its outskirts. −Master thesis, Botany Department, Govt, Post-graduate collegeBannu.

Nusser, M and Dickore, B. 2002. A tangle in the triangle: vegetation map of the eastern Hindukush (Chitral, Northern Pakistan). Erdkunde. 56 (1): 37−59.

Odum, E. P. 1971. Fundamentals of ecology, 3rd (ed.) W.B. Saunders, Philadelphia, PA.

Palmer, M. 2005. Ordination methods for Ecologists.http://ordination.okstate.edu/.

Parker, G. G., Harmon, M.A and Lefsky, J. Q. 2004. Three dimensional structure of an old growth *Pseudotsugatsuga* canopy and its implications for radiation, microclimate and gas exchange. Ecosystems. 7: 440-53.

Rahman, A. H. M. M., Anisuzzaman, M., Haider, S.A., Ahmed, F., Islam, A. K. M. R and Naderuzzaman, A. T. M. 2008.Study of medicinal plants in the Graveyards of Rajshahi city.Research Journal of Agriculture and Biological Sciences.41: 70-74.

Ringrose, S., Matheson, W., Wolski, P and Huntsman-Mapila, P. 2003. Vegetation cover trends along the Botswana Kalahari transect. Journal of Arid Environments.54: 297- 317.

Ryniker, K. A., Bush, J. K and Auken, O.V. 2006. Structure of *Quercus gambelii* communities in the Lincoln National forest New Mexico, USA.Forest Ecology and Management. 233: 69-77.

Sagers, L. C and Lyon, J. 1997. Gradient analysis in a riparian landscape: contrasts among forest layers. Forest Ecology and Management. 96:13-26.

Shaltout, K. H., El-Kady, H. F and Al-Sodany, Y. M. 1995. Vegetation analysis of the Mediterranean region of Nile Delta.Vegetation. 116: 73-83.

Siddiqui, F. M. 2011. Community structure and dynamics of conifers forests of moist temperate area of Himalayan region of Pakistan. PhD dissertation Department of Botany Federal Urdu University Karachi Pakistan.

Siddiqui, F. M., Shaukat, S. S., Ahmed, M and Khan, I. A. 2013. Vegetation-environment relationship of conifer dominating forests of moist temperate belt of Himalayan and Hindukush regions of Pakistan.Pakistan Journal of Botany. 45 (2): 577-592.

Song, C., Huan, L. G and Sheng, L. Q. 2009. Spatial and environmental effects on plant communities in the Yellow River Delta, Eastern China. Journal of Forestry Research. 20 (2): 117−122.

Speer, J. H. 2010. Fundamentals of Tree-Ring Research.The University of Arizona Press. Tucson.

Stewart, R. R. 1982. History and exploration of plants in Pakistan and adjoining areas. Pan Graphics: Ltd., Islamabad.

Timilsina, N., Ross, M. S and Heinen, J. T. 2009. A community analysis of Sal (Shorearobusta) forests in the western Terai of Nepal. Forest Ecology Management. 241 (1/3): 223-234.

Wahab, M. 2011. Population dynamics and dendrochronological potential of pine tree species of District Dir Pakistan. *Ph.D*dissertation Department of Botany Federal Urdu University Karachi Pakistan.

Whittaker, R. H. 1970. Communities and Ecosystems. Macmillan, New York.

Yousifzai, S. 2012. Population Structure and Dynamics of *Dodonaea*viscosa (Linn) Jacq. In Malakand Division, unpublished Ph.D. thesis, Department of Botany, University of Malakand.

Zhang, J-T and Zhang, F. 2007.Diversity and composition of plant functional groups in mountain forests of the Lishan Nature Reserve, North China. Botanical Studies 48:339–348.