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Ordination and Classification of Vegetation in Semi Arid Area of Pakistan

By Musharaf Khan, Farrukh Hussain, Faridullah & Shahana Musharaf
Federal Government College Mardan, Pakistan

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Ordination and Classification of Vegetation in Semi Arid Area of Pakistan

Musharaf Khan [α], Farrukh Hussain [σ], Faridullah [ρ] & Shahana Musharaf [ω]

Abstract- A survey of natural vegetation of Tehsil Takht-e-Nasrati, District Karak was undertaken in spring 2010-2011. Total 66 species were recorded during spring. Hierarchical Cluster Analysis (HCA), and Detrended Correspondence Analysis (DCA) were used for the plant community analysis. Plant species of each community type are presented together with the information on dominance and sub-dominance species. Four plant co- mmunities association i.e. Prosopis-Fagonia-Saccharum association, Zizyphus-Saccharum-Acacia association, Fagonia-Zizyphus-Eragrostis association and Aerua-Acacia-Cymbopogon association were recognized. Classification and ordination techniques provided very similar results based on the floristic composition and communities similarity. The results produced the source for the mapping division of plant life communities.

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I. Introduction

Ordination techniques are commonly used in phytosociology. This may be done either by arranging the points along the axis or by forming the scatter diagram with two or more axis. Detrended Correspondence Analysis (DCA), an indirect gradient analysis technique in which the distribution of species is not controlled by environmental variables rather, it focuses to analyze the pattern of species distribution. Environmental data for DCA is not required and species data is used to assume the gradients (Sagers & Lyon, 1997). Ordination techniques are widely used by the ecologists to study the relationship between vegetation and environment. Khaznadar et al., (2009) conducted a study in Chott El Beida wetland, a RAMSAR site in Setif, Algeria to study distribution of plants community and environmental factors. The collection was done from sixty vegetation plots. TWINSPAN and Detrended Correspondence Analysis (DCA) were used as the analysis techniques. A similar study was conducted by Ahmad et al., (2010) along motorway (M-2), Pakistan using multivariate techniques i.e., DECORANA. Results showed two major and sixteen sub-communities from 397 quadrats. The study was helpful for implementation and conservation planning and for the improvement of road sides. To study the relationship between vegetation and environment, a study was conducted by He et al., (2007) in the Alxa Plateau of Inner Mongolia, China which resulted in the detection of six characteristics vegetation groups by using the Detrended corr-espondence analysis (DCA). Ahmad (2009) studied the herbaceous vegetation in Margalla Hills National Park, Islamabad, Pakistan. Four vegetation groups were recognized by TWINSPAN. El-Bana et al., (2009) studied *Juniperus phoenicea* L. and associated vegetation at three mountains in Egypt, resulted in the recognition of four vegetation types along with juniper by TWINSPAN and DCA analysis techniques. Jabeen and Ahmad (2009) conducted a study to analyze the vegetation and environment data of Ayub National Park, Rawalpindi. PCOrd 5 and CANOCO 4.5 were used and data was recorded by quadrat method. 44 plants species from 30 quadrats were recorded. Many researchers (Dasti & Malik, 1998; Malik & Hussain, 2008; Saima et al., 2009; Ahmad, 2009; Ali & Malik, 2010; Ahmad et al., 2010; Khan & Hussain, 2012) have studied different aspects of vegetation structure and classification and ordination distribution patterns in different parts of Pakistan. Classification and ordination is an invaluable method for vegetation survey and assessment involving inv-estigation of characteristics of plant communities using simple and rapidly employing field techniques (El-Ghanim et al., 2010). In the present study, an effort has been made to investigate and analyse correlation of communities with key environmental factors. The Tehsil Takht-e-Nasrati comprises one of the richest and most interested ecosystems on earth. The community structure and distribution patterns of research area have not been given due attention till the date by the plant ecologists, and hence poorly understood (Khan, 2012). The particular objectives of present study include quantifying the vegetation in spring season of Tehsil Takht-e-Nasrati, District Karak using ordination techniques for upcoming conservation and providing base line data of ecological important area.

II. Research Area

The Tehsil Takhti Nasratti is situated at 32.47o to 33.28o North and 70.30 o to 71.30o East. The Tehsil is bounded by Tehsil Banda Dawood Shah on the North West, Tehsil Karak on the North East, District Mianwali and District Lakki Marwat on the South East, and Tribal

Author α : Department of Biological Science, Federal Government College Mardan, Pakistan.
Author σ : Department of Botany, Bacha Khan University Charsadda, Pakistan.
Author ρ: PCSIR Laboratories Peshawar, Pakistan.
Author ω: Department of Chemistry, Government Girls Degree College, Sheikh Maltoon, Mardan, Pakistan.

area Adjoining District Bannu on the South West (Fig. 1). The total area of Tehsil is about 613.66 Sq. kilometer. Majority of the area consists of rigged dry hills and rough fields areas i.e. 323.97 Sq. kilometers and agriculture land is about 289.7 Sq. kilometer. The major income source of the people is Agriculture, which is rain depended. The area is situated at 340 m above the sea level. In the year 2010, 62.5 mm. y-1 of rainfall recorded. The area is very hot in summer and very cold in winter. June and July are the hottest months, where as December and January are the coldest months. In the year 2010 the mean maximum temperature was 39.5 Co, in the month of the May, where as the mean minimum temperature was as low as 4 C o, in the month of January. The wind speed was different in different years. In the year 2009 the wind speed was high 6 Km per hour (h) in the month of July whereas in the year 2010 it was high in the month of April 7.2 Km. h-1 (Table 1).

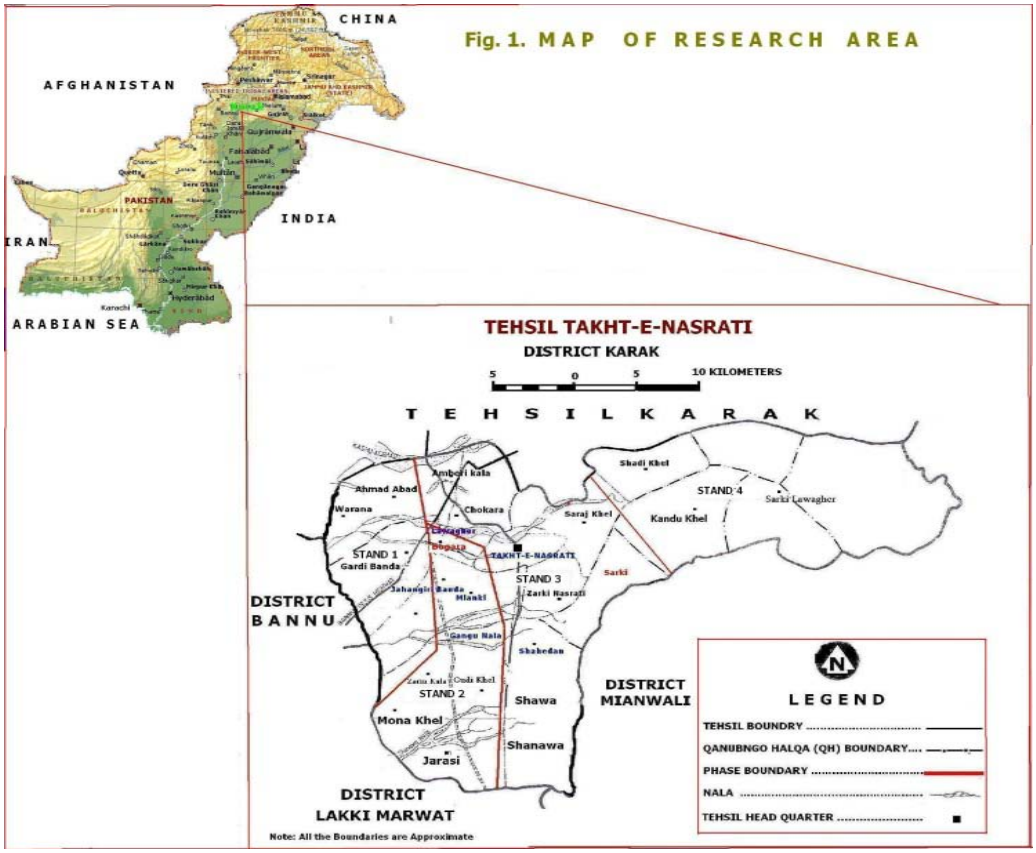

Figure 1 : Map of Tehsil Takht-e- Nasrati showing research spots.

Table 1 : Meteorological data of Tehsil Takht -e –Nasrati, District Karak for the year 2001-2010.

Months	Temperature (C°)		Humidity (%)		Rainfall (mm)	Soil temperature (C°) Average	Wind speed (Km Per Hour)
	Max	Min	Max	Min			
January	19.18	4.26	75.80	35.24	27.43	7.03	2.9
February	21.69	7.29	77.39	42.23	37.72	9.14	3.2
March	28.20	12.06	75.38	35.23	37.17	13.89	3.5
April	34.74	17.94	66.12	29.42	36.54	19.02	5.2
May	38.32	22.33	59.66	30.73	31.6	21.87	5.4
June	39.50	25.9	59.96	32.89	74.24	25.78	5.5
July	38.44	25.76	73.33	38.76	121.6	26.77	5.2
August	36.66	25.29	75.68	42.61	108.3	26.37	4.1
September	35.47	21.95	77.21	39.29	61.58	23.49	3.7
October	32.33	16.79	71.55	35.51	15.13	20.09	3.5
November	26.71	10.01	71.56	36.66	5.80	14.10	3.2
December	21.93	5.67	75.20	35.90	15.38	8.96	3.1
Mean	31.1	16.27	71.57	36.21	47.71	18.04	4.04

Source : Agricultural Research Farm Ahmad Wala Karak.

III. Materials and Methods

a) Field data collection

Floristic data were collected from 22 randomly selected sites from 4 stand selected on the basis of altitude. Quadrat method was used for the collection of vegetation data. Each field site comprised of 10 Quadrats for each plant layer i.e. tree (10X10m), shrubs (5X5m) and herbs (1X1m). The latitude and longitudes were recorded for each site using a Global Positioning System (GPS). Sampling was completed in spring season. The spring season starts in March -April, when most of the plants are in flowering stages. Collected samples were pressed, dried and transported to herbarium of University of Peshawar Khyber Pakhtunkhawa, Pakistan, where they were identified and classified following Stewart (1972) and Nasir and Ali (1972) and a fraction of angiosperms of Tehsil Banda Daud Shah by Khan, (2004).

b) Data analysis

Vegetation attributes including frequency, density and cover were recorded along with environmental coordinates like latitude, longitude, altitude and slope using GPS. The importance value of each species was compiled adding RD, RF and RC following Hussain (1989). On the basis of the highest importance values of the first three dominant species from each layer, the communities were established and named. All the species data, as well as the field sites communities, were used for the analysis. The data was classified using standard methods Hierarchical Cluster Analysis (HCA) and Detrended Correspondence Analysis (DCA) (Hill, 1979) to summarize biological records and position of communities in groups during spring. The plant life associations were named after the highest value of three dominant species. DCA ordination offered two significant ordination axes on the basis of weight for communities. Detrended Correspondence Analysis (DCA) were performed to describe compositional gradients in the vegetation. All analysis was performed using the software PCORD ver. 4.16 (McCune & Mefford, 1999).

IV. Results

The arrangement of plant life record is commonly vegetation orientation and main query disquiets the classification and explanation of the vegetation in addition to inconsistency of ecological arrangement. Distinctive multivariate techniques are generally fruitful and commonly used for plant life arrangement position. Though, distinctive multivariate analyses do not directly take into explanation relations in their computation and are not particularly designed to vegetation structures rationalization. The ordination may be defined as the position of communities designed to set apart group types, location, relative position, standing of communities in a season of particular area. In other words, the ordination is the sound or clear arrangement of split communities or species in a season of a particular area. In present work the ordination of communities in spring is given as follows:

a) Hierarchical Cluster Analysis

In spring season, 66 species were present in 22 communities in 4 different stands on the basis of altitude. The Hierarchical Cluster Analysis shows that the relationship among 22 communities during spring were inclusion iv into 21 cluster cycling where in cycle 1 it shows the relation of 2 communities at 1.0928E+03 and last i.e. cycle 21, 22 communities were connected with one another at 1.0144E+05 with 3.29 % chaining. Further more, on the basis of relationship it marked out distinct 4 groups associations by different level, cycling and similarity of communities. The depiction of each one group association is as below:

i. *Prosopis-Fagonia-Saccharum association*

In group 1, 32 species comprising 6 trees, 6 shrubs and 20 herbs and grasses were present. The dominant species of association with highest mean important value were *Prosopis farcta* (IV = 28.4), *Fagonia cretica* (IV = 22.6) and *Saccharum bengalense* (IV = 21.9). Furthermore, it comprises 4 communities i.e. *Prosopis-Saussurea-Saccharum* community (PSS), *Prosopis-Periploca-Aerua* community (PPA), *Fagonia-Prosopis-Saccharum* community (FPS) and *Phoenix-Saussurea-Saccharum* community (PSS) which raised at 4.2195E+04 in cycles 15 (Table 2; Fig. 2).

ii. *Zizyphus-Saccharum-Acacia association*

The group 2 becomes visible at 4.8435E+04 in cycle 16 that contains *Acacia-Saccharum-Citrullus* community (ASC), *Calligonum-Zizyphus-Saussurea* community (CZS), *Zizyphus-Cenchrus-Saccharum* community (ZCS), *Zizyphus-Aerua-Calligonum* community (ZAC), *Zizyphus-Saccharum-Cynodon* community (ZSC) and *Zizyphus-Calligonum-Fagonia* community (ZCF). Moreover, 42 species in which 4 trees, 7 shrubs and 31 herbs were present. Where mean highest important value was represented by *Zizyphus maurtiana* (IV = 54.08), *Saccharum bengalense* (IV = 19.84) and *Acacia nilotica* (IV = 17.26) (Table 2; Fig. 2).

iii. *Fagonia-Zizyphus-Eragrostis association*

In cycle 17 at 5.5773E+04, the *Fagonia-Zizyphus-Eragrostis* association was structured that composed of 47 species of 7 trees, 14 shrubs and 26 herbs in which the mean highest important value 34.5, 28.1 and 19.9 presented *by Fagonia cretica*, *Zizyphus maurtiana and Aerua persica* respectively. It consists of 6 communities i.e. *Fagonia-Zizyphus-Saccharum* community (FZS), *Fagonia-Phoenix-Capparis* community (FPC), *Fagonia-Withania- Zizyphus* community (FWZ), *Dichanthium-Withania-Zizyphus* community (DWZ),

Eragrostis-Zizyphus-Capparis community (EZC) and *Salvia-Zizyphus-Rhazya* community (SZR) (Table 2; Fig. 2).

iv. *Aerua-Acacia-Cymbopogon association*

In *Aerua-Acacia-Cymbopogon* association, 34 plant species comprising 5 trees, 11 shrubs and 18 herbs and grasses were present. The dominant species on the basis of important value were *Aerua persica* (IV = 49.4), *Acacia modesta* (IV = 21.2) and *Cymbopogon jwarancusa* (IV=20.9). It was structured at 6.3334E+04 in cycle 18 covering *Cymbopogon-Rhazya-Zizyphus* community (CRZ), *Aerua-Saccharum-Zizyphus* community (ASZ), *Aerua-Rhazya-Acacia* community (ARA), *Aerua-Punica-Acacia* community (APA), *Aerua-Acacia-Capparis* community (AAC) and *Zizyphus-Aerua-Capparis* community (ZAC) (Table 2; Fig. 2).

b) Detrended Correspondence Analysis (DCA)

Ordination of the communities by DCA explains that the communities with high weight and structured 4 groups. On Axis 1, the groups 4, 3, 2 & 1 were structured with mean DCA weight 241, 138, 34.6 and 23.8 at Eigen values of axes (0.495) respectively. While on Axis 2, the 1, 2, 3 and 4 groups were produced with mean DCA weight as 145, 74, 135 and 69 at EIG (0.206) respectively. Furthermore, the group 1, 2, 3 and 4 were composed of 4, 5, 3 and 5 communities respectively. Other communities that were not present in groups were ASC, CZS, EZC, FPC and FPS with DCA weight 231, 221, 67, 84, 207 at Axis 1 and 220, 190, 116, 88 and zero at Axis 2 respectively. These groups show different vegetation types during spring seasons (Fig. 3).

V. Discussion

Cluster analysis segregates the communities of similar character into major groups of plant life. In spring, 4 groups were structured. The chaining percentage between communities association was high 3.29 in spring. From this it was noticed that the chaining percentage would be high with high quantity and presence of species in an area. In spring, species were mostly found in all sites in less or high quantity while species presence is restricted to specific area due to diverse factors. Most factors that occur during spring in under investigated area were high grazing, cutting, non availability of water, soil erosion and uprooting of plant species. Ahmed & Yasmin (2011) analyzed natural vegetation of two zones along Hanna Lake, Baluchistan using DECORANA and classify the vegetation into plant communities. Major group is the objective to give structure to plant life. However, cluster analysis is a helpful preliminary position for competent judgment and adjoining neighbors of vegetation. Greater the homogeneity within communities and greater will be the similarity in the clustering. The cluster analysis was used to give clear picture of the plant life in an area in the form of tree - shape. In hierarchical clustering the principle is to structure a hierarchical chain of communities' groups sorting from groups of community position at the bottom to a comprehensive group at the top. The graphically diagram which represents the hierarchy in the structure of upturned tree expresses a dendogram that clarifies the arrangement in which position were united (bottom-up outlook) or group were divide (top-down outlook).

Detrended Correspondence Analysis (DCA) was used to give the shape to the communities on the basis of weight. This method is also used to give cleared picture of plant life in specific area in spring season. The present results conclude that the plant species composition was different in spring season in the same area. On axis 1, communities DCA weight was high in plains and low in hilly area. However, DCA has limitations, making it best to remove extreme outliers and discontinuities prior to analysis. DCA consistently gives the most interpretable ordination results, but as always the interpretation of results remains a matter of ecological insight and is improved by field experience and by integration of supplementary environmental data for the plant life sample sites. Ali & Malik (2010) applied the Detrended Correspondence Analysis (DCA) to identify environmental gradients to define vegetation distribution in green belts, gardens and parks of Islamabad city and classified the flora into 4 major association groups. El-Ghanim et al. (2010) studied the vegetation at Hail region north of central Saudi Arabia where multivariate techniques results showed 7 vegetation groups. Ahmad et al. (2010b) analyzed the vegetation along motorway (M-2), Pakistan by using multivariate techniques. In the investigated area, the fore mentioned facts noticeably indicate that slope, edaphic factor, harsh erosion, crushing of herbs and supply of rain water were the key source of plant life discrepancy. These geomorphologic aspects restrict the limitations and composition of plant communities. Distant from the reality that the site changeable are definitely significant for explaining the major plant life nature the association between the results of cluster analysis and DCA planes allow a direct analysis of scores of position data in DCA plane in relation to area up-and-down. The DCA technique provided interpretable and dynamic results than other ordination techniques and the length of first axis was greater than 3.0 and in terms of communities or species turnover. Jongman et al. (1995) recommended that if plants species or communities turnover is larger than 1.9 standard deviation then DCA techniqe is advanced option of ordination. Detrended Correspondence Analysis (DCA) was carried out to express compositional ascents in the plant life. DCA was presented using a default value for rescaling and detrending. Rare species and divergent communities were downweighted in DCA ordination.

The different association produced by cluster analyses are designed a first two axes as a sprinkled diagram. The DCA ordination axes may signify in same way the main substrate weight that affect the community in these records and have been used by the community and area characteristic of the relationship to argue the dominant characteristics of the location and plant life association. Cluster and DCA analysis are very helpful in communities' and species classification in addition to give structure to plant life. Such type of study was also carried out by Saima et al. (2009) who stated that tree density, pH and soil texture were the major determinant of vegetation pattern. There was thin vegetation in the investigated area and species was present in patches. The ecologists have tried to quantify the division of species beside the ecological gradients. There is an association between plant life sample and resources available (Ahmad et al., 2009b and Jabeen & Ahmad, 2009). The ordination by means of cluster analysis and DCA help us skillfully in evaluating the classification of plants and structure of entire habitat of plant life. Malik & Hussain (2008) conducted a study to work out the relationship between remote sensing data and vegetation communities of ecological importance using multivariate techniques and stated that the ordination methods proved effective in summarizing basic, general structure of the plant community types and to some extent indicated correspondence with their spectral signatures. This study pointed out that the climatic environment of region has restricted enlistment of area and the plant life was changed with the change of seasons and altitude. Our result agrees with Dasti & Malik (1998) who stated that altitude is an environmental factor which affecting plants association. Plant ecologists have commonly been aware that plant life shows an inconsistency over a wide range of particular scales and area that have built up methods for studying the classification of vegetation. The area show less rainfall than 200 mm and consist of thorny trees like *Zizyphus spp*, A. *nilotica,* A. *modesta*. Trees are sprinkled, roots longs, leaves thick and small in most plant species therefore, the investigated area fall into tropical thorn forests. The value of altitude as an ecological factor affecting plant species association is not considering, surprising its close correlation with precipitation and interruption of rain (Danin et al., 1975; Evenari et al., 1982).

VI. Conclusion

The study demonstrated the potential of different classification and ordination analysis such as HCA and DCA in detecting the main environmental gradients and one could isolate a subset of environmental factors that led to a reasonable (ecologically meaningful) interpretation for important gradients in a few dimensions. It is used as a perfect way to study and helps skillfully in evaluating the biodiversity and conservation of intact habitat and plant life in specific area. This study pointed out that climatic environment of region has privileged conscription of area and association of plant was changed with the change of altitude. Plant ecologists have commonly been conscious that vegetation shows a discrepancy over a broad variety of particular scales and area. Therefore, it is needed that we apply the multivariate techniques i.e. HEC and DCA methods for studying the degree of plant life differences.

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Table 2 : Mean relative importance value of species in different associations during spring distinguished through cluster analysis of Tehsil Takht-e-Nasrati, Karak.

S. No	Species Name	Groups			
		1	2	3	4
1	*Acacia modesta* Wall.	0	0	7.55	21.2
2	*Acacia nilotica* (L.) Delice.	4.6	17.3	5.56	4.07
3	*Dalbergia sissoo* Roxb.	2.9	12.4	0.79	2.97
4	*Gymnosporia royleana* Wall. ex M. A. Lawson.	0	0	0.78	0
5	*Monotheca buxifolia* (Falc.) A.D.	0	0	1.02	0
6	*Phoenix dactylifera* L.	16.6	0.87	10.7	1.32
7	*Prosopis farcta* (Banks & Sol.) J.F. Macbr.	28.4	0	0	0
8	*Prosopis juliflora* (Sw.) DC.	0	0	0	0.86
9	*Tamarix aphylla* (L.) Karst.	2.03	0	0	0
10	*Zizyphus maurtiana* Lam.	14.2	54.1	28.1	19.7
11	*Astragalus psilocentros* Fisch.	0	1.9	2.09	8.88
12	*Calligonum polygonoides* L.	0	15.3	2.3	0
13	*Calotropis procera* (Wild.) R. Br.	9.79	10.3	5.59	2.24
14	*Capparis decidua* (Forssk.) Edge worth.	0	0	7.49	11.9
15	*Capparis spinosa* L.	0	0	0	8.5
16	*Cassia angustifolia* Vahl.	0	0	3.19	0
17	*Datura metel* L.	13	7.99	1.1	0
18	*Periploca aphylla* Decne.	12.7	5.28	3.26	0.73
19	*Punica granatum* L	0	0	0	8.81
20	*Rhazya stricta* Decne.	0	0	15.7	20.2
21	*Ricinus communis* L.	6.5	2.83	0.83	0
22	*Saccharum bengalense* Retz.	21.9	19.8	6.34	9.02

23	*Saccharum spontaneum* L.	1.38	0	3.03	0.75
24	*Withania coagulans* (Stocks) Dunal.	0	0	14.2	2.15
25	*Zizyphus nummularia* (Burm.f.) W. & A.	0	0	4.87	4.93
26	*Aerua persica* (Burm.f.) Merrill.	16.3	5.28	19.9	49.4
27	*Asparagus gracilis* Royle.	0	5.98	4.19	9.25
28	*Asphodelous tenuifolius* Cavan.	0	2.15	2.27	0
29	*Cenchrus biflorus* Hook. f.	4.17	0	0	0
30	*Cenchrus ciliaris* L.	0	12.3	15.9	12.8
31	*Centaurea iberica* Trev.Ex. Spreng	0	0	1.32	1.53
32	*Chenopodium album* L.	2.7	4.76	0	0
33	*Citrullus colocynthis* L. Schrad.	1.7	5.57	1.32	0
34	*Convolvulus arvensis* L.	6.9	2.3	0	0
35	*Convolvulus pluricaulis* Choisy.	0	0	2.82	7.64
36	*Crotalaria medicaginea* Lam.	0	1.22	0	0
37	*Cymbopogon jwarancusa* (Jones) Schult.	0	0	0	20.9
38	*Cynodon dactylon* (L.) Pers.	5.08	3.4	13.1	8
39	*Cyperus rotundus* L.	0	3.65	1.41	0
40	*Dichanthium annulatum* (Forssk) Staph.	0	0	11.5	8.44
41	*Echinops echinatus* D.C.	0	2.18	9.08	7.16
42	*Eragrostis poaoides* Beauv.	12.9	11.9	21.7	19
43	*Erodium malacoides* (L.)L. Her. Ex Ait.	0	0.81	0	0
44	*Euphorbia helioscopia* L.	5.89	6.44	0	0
45	*Euphorbia prostrata* Ait.	2.47	4.37	0	0
46	*Fagonia cretica* L.	22.6	6.68	34.5	8.2
47	*Hypecoum pendulum* L.	0	3.53	0	0
48	*Ifloga fontanesii* Cass.	12.1	10.7	0	0
49	*Ipomoea hederacea* (L.)Jacq.	0	0	1.32	0
50	*Kickxia ramosissima* (Wall) Janchen.	0	1.63	0	3.3
51	*Launaea nudicaulis* (L.) Hook. f.	0	7.7	8.1	4.25
52	*Malcolmia africana* (L.) R.Br.	1.8	2.04	0.66	0.44
53	*Malva parviflora* L.	0	2.75	0.98	0
54	*Malva neglecta* Wallr.	0	4.58	0.98	1.87
55	*Medicago laciniata* (L.) Mill.	0	0	0.49	1.66
56	*Melilotus indicus* (L.) All.	0	3.87	0	0
57	*Peganum hermala* L.	7.6	0	0	0
58	*Plantago ciliata* Desf.	9.9	4.34	0	0
59	*Plantago ovata* Forssk.	11.1	4.3	0	0
60	*Solanum nigrum L.*	4.99	3.3	0.75	0
61	*Salvia moorcroftiana* Wallich ex Benth.	0	0	12.4	0
62	*Saussurea heteromalla* (D.Don) Hand.	20.5	7.61	1.97	0
63	*Silene conoidea* L.	3.01	2.93	0.66	0
64	*Solanum incanum* L.	0	0	2.41	3.63
65	*Solanum surattense* Burm .f.	9.64	4.63	4.17	4.3
66	*Vicia sativa* L.	4.65	9.03	1.61	0

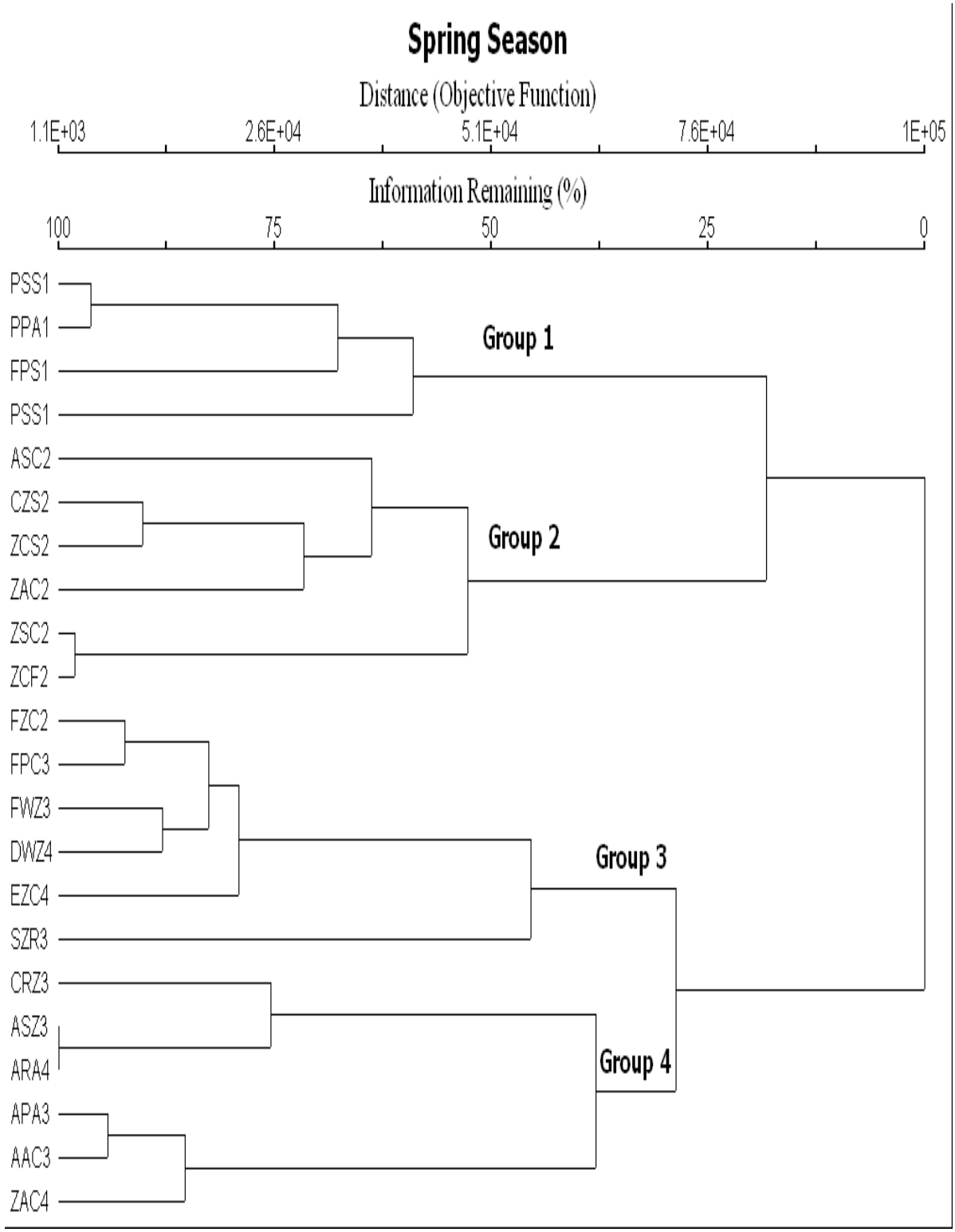

Figure 2 : Two way cluster dendrogram showing grouping of different communities into association during spring, Tehsil Takht-e-Nasrati, District Karak.

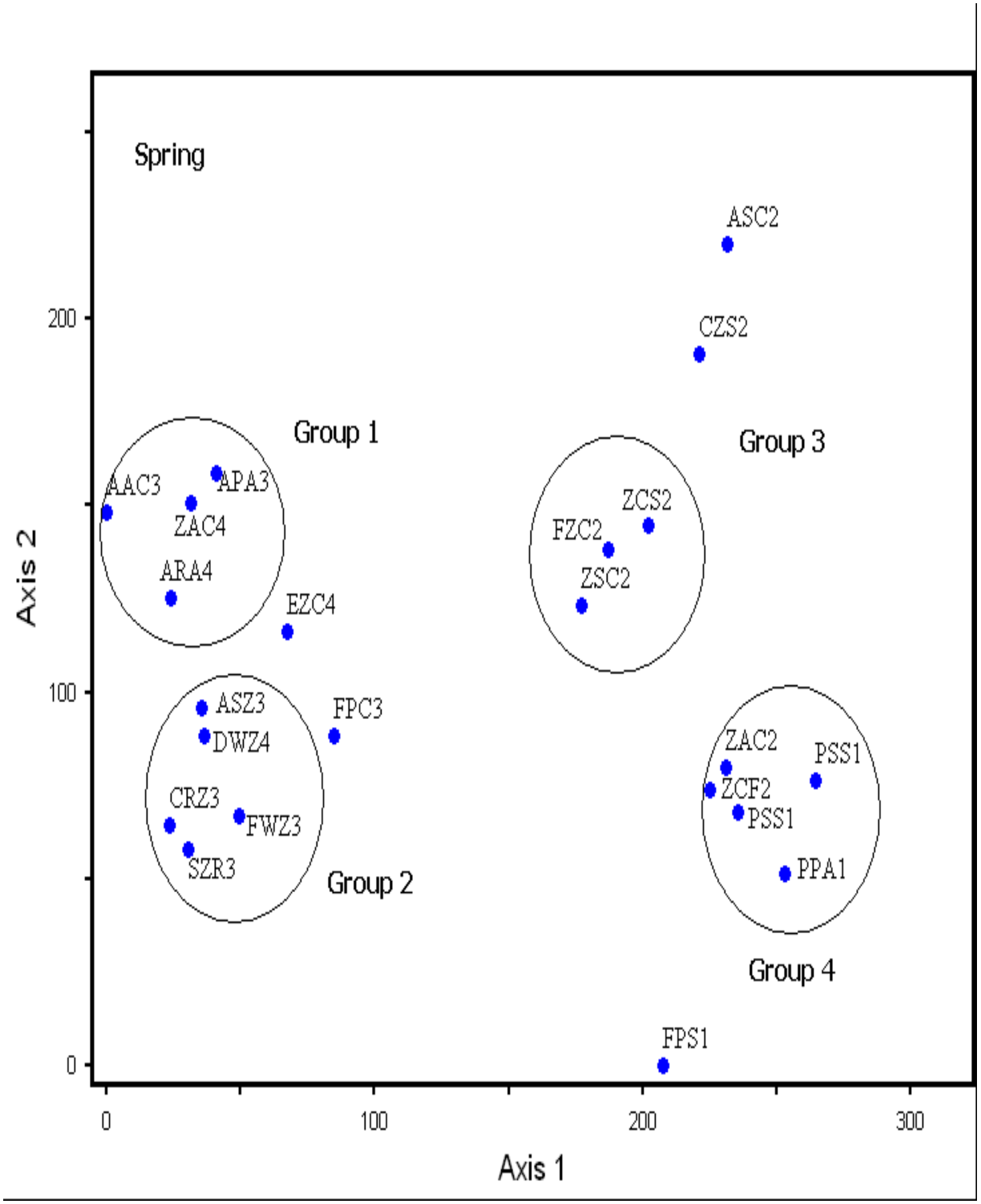

Figure 3 : Detrended Correspondence Analysis (DCA) of communities during spring, Tehsil Takht-e-Nasrati, District Karak.