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Spatio-temporal Effects on Species Classification of Medicinal Plants in Soone Valley of Pakistan

IFTIKHAR AHMAD, MUHAMMAD SAJID AQEEL AHMAD[1], MUMTAZ HUSSAIN, MANSOOR HAMEED, MUHAMMAD YASIN ASHRAF†, MUHAMMAD SAGHIR‡ AND SHAISTA KOUKAB¶
Department of Botany, University of Agriculture, Faisalabad, Pakistan
†Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, Pakistan
‡Barani Agricultural Research Institute, Chakwal, Pakistan
¶Arid Zone Research Centre, Quetta, Pakistan
[1]Corresponding author: e-mail: sajidakeel@yahoo.com

ABSTRACT

Soone Valley of Salt range in Pakistan was investigated to determine the distribution pattern of vegetation especially medicinal plant diversity at different sites and seasons. Six sites were selected on the basis of variation in their environmental [elevation, slope, aspect (western/northern), altitude, topography and soil composition] and community attributes [habitat, vegetation type & plant community structure]. The ecological data for autumn, winter, spring and summer seasons were recorded during last weeks of September, December, March and June, respectively. Results revealed that most of the species were frequent during summer as compared to other seasons, which was correlated with suitable temperature, enough moisture and availability of macronutrients during summer. Among sites most of the species were more frequent in Khabeki and Khoora sites, which seemed to be associated with high macronutrient availability and field capacity. Salt and drought tolerant species were associated with Jallar site. On the other hand, moisture loving and moderately moisture requiring species were found equally distributed between the Knotti Garden and Dape Sharif. *Justicia adhatoda* was the only frequently occurring medicinal plant during most of the seasons and at maximum sites, whereas the distribution of other species was mainly restricted to a particular season or site. It was concluded that soil moisture, salts and availability of macro-and micronutrients were the major determinants of species distribution in the studied area.

Key Words: Soone valley; Classification; Medicinal plants; Seasons; Species distribution

INTRODUCTION

Species classification is generally used to assess the diversity and status of plant species. Based on different criteria, plant species are generally classified in different groups e.g., dominant, abundant, rare etc. For example, Dyksterhuis (1949) classified range species using percent cover and assigned them the terms like decreaser, increaser and invader. In addition, based on quantitative ecology, he classified range conditions into excellent, good, poor and very poor. Hanson (1951) classified bunch type range land into four classes depending on the observed vegetation composition, soil condition, plant vigor and lesser degree on plant density. Hussain (2002) classified various plant species based on density and frequency percentage.

The Soone Valley is located between longitudes 72°00 and 72°30 E and latitudes 32°25 and 32°45 N. It is surrounded by two parallel east-west longitudinal ridge systems, covering an area of 300 km^2. The average elevation of the area is 762 m and the highest adjacent point is the Sakesar Top being 1522 m above sea level (Afzal *et al.*, 1999). The climate of the valley is characterized by a relatively low annual precipitation (50 cm) and average minimum temperature of 1°C during January, while average maximum temperature is 36°C during June. Prolonged periods of drought are frequent and winters are accompanied by frost (Hussain, 2002).

The dominant vegetation of this valley comprises of *Justicia adhatoda, Achyranthus aspara, Acacia modesta, A. nilotica, Albizzia lebbeck, Melilotus alba, Capparis deciduas, Chenopodium album, Calotropis procera, A. farnesiana, Datura metel, Fumeria indica, Olea ferruginea, Peganum hermala* and *Mentha longifolia* (Ahmad *et al.*, 2002; Hussain, 2002). These and many other species are traditionally popular as healing agents and have been used by indigenous people for the treatment of various diseases (Ahmad *et al.*, 2002).

Although a number of surveys were conducted in salt range reporting the biodiversity and floral composition (Ahmad, 2002), little information is available on the

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spatiotemporal effects on species classification of medicinal plant species located in this area. Therefore, it was necessary to locate different species especially that of medicinal plants during different seasons and sites and evaluate their classification status in order to determine their conservation value.

MATERIALS AND METHODS

General details. This study analyzed the vegetation of Soone valley in Salt Range of Pakistan during 2005-06. The distribution pattern of vegetation especially medicinal plant diversity was determined at different sites and seasons and their conservation status was evaluated for proper conservation practices of these important medicinal plant species. Soone Valley was extensively surveyed and the available species at selected sites were enlisted. In order to collect a comprehensive list of plant parts used for medicinal purposes, meetings were arranged with local herbalists (people curing various diseases with plant extracts), older peoples having traditional plants knowledge, government officials from Department of Forestry and Agriculture and various Non-Government Organizations such as SVDP (Soone Valley Development Project).

Selection of sites. On the basis of a preliminary survey six ecologically diverse study sites namely Khabeki, Khoora, Dape Sharif, Anga, Knotti Garden and Jallar were selected based on differences in their environmental attributes especially variations in elevation, slope, altitude, topography, soil composition and community attributes such as habitat, vegetation type and plant community type. Meteorological data for rain fall, maximum and minimum temperature were obtained from Horticultural Research Station of Soon Valley for the entire study period (Ahmad *et al.*, 2008).

Ecological analysis of the vegetation. The plants were collected from their natural habitats at different sites in Soone Valley during all the four seasons. For autumn, winter, spring and summer seasons the ecological data were recorded during last weeks of September, December, March and June, respectively. The plants were identified with the help of Flora of Pakistan (Qaiser & Nazimuddin, 1981) and specimens mounted on herbarium sheets were deposited in the Herbarium of Department of Botany, University of Agriculture, Faisalabad, Pakistan.

Ecological data were recorded using Random Quadrat Sampling Method (Silvertown & Lovett-Doust, 1993; Henderson, 2002). Fifteen fixed quadrats of 1 m^2 for herbs and 5 m^2 for shrubs and trees were used at each site and individual plants in the quadrats were counted. Primary data were used for the calculation of frequency and relative frequency of species using the following formulae:

$$\text{Frequency } (\%) = \frac{\text{No. of quadrates in which a species occurred}}{\text{Total No. of quadrates taken}} x100$$

$$\text{Relative Freq. } (\%) = \frac{\text{Frequency value of a particular species}}{\text{Total Frequency values of all the species}} x100$$

Species classification. Species were classified depending upon the frequency of the species at each season and site with the help of the key (System Kult) developed by Kult (1947) based on the following criteria:

Frequency Range (%)	Category	Symbol
1- 20	Rare	R
21- 40	Occasional	O
41-60	Frequent	F
61-80	Abundant	A
81-100	Very abundant	VA

Statistical analyses. The data for different ecological attributes was analyzed using Canoco Computer Package for Windows [Version 4.5]. Partial Canonical Correspondence Analysis (*p*CCA) technique was applied keeping seasons as a variable and sites as a co-variable and vice versa. The Multivariate Direct Gradient Model was fitted and all variables (nominal) were plotted on *p*CCA Axis 1 and 2. All species were arbitrarily grouped based on their clustering pattern for a particular season or site.

RESULTS

The results of this study revealed that the species frequency varied significantly during all the four seasons ($P<0.001$, eigen values, 0.071; Table I). The *pCCA* biplot of frequency data regarding seasons as environmental variables and sites as a co-variables showed that most of the species (group-I) clustered around summer. Frequency of few species in group II was associated with autumn. Some species as *Adiantum capillus-veneris*, *Alternanthera sessilis*, *Barleria cristata* and *Parthenium procumbens* were equally frequent during summer and autumn. Another group of species (group-III) was abundant both during spring and summer. Some species as *O. ferruginea*, *Prosopis glandulosa, Ziziphus mauritiana, Sophora tomentosa, J. adhatoda, Withania coagulens, Nerium oleander* and *Saccharrum munja* were associated with summer spring and winter. Winter had no or very little association with most of the species (Fig. 1a).

Similarly, sites also had a significant effect on the frequency of the medicinal plant species of this area ($P<0.001$, eigen value 0.248; Table I). The *pCCA* ordination biplot of frequency of species and sites showed that most of the species (group-I & II) were associated with Khoora site. In group-II most of species were frequent at Anga and Khabeki sites. In group-III *M. longifolia* and *Tinospora malabarica* were frequent at Knotti Garden. At Dape Sharif, species of group-IV were frequently associated. Species of group-V were associated with Dape Sharif but less than group-IV. Species of group-VI were equally associated with Anga, Khabeki and Knotti Garden sites. Species of group-VII were associated with Jallar, while species of group-VIII were frequent more at Knotti Garden and Dape Sharif (Fig.

Table I. Summary of the partial CCA of the vegetation data for frequency and environmental data for seasons and sites

Parameters and data	Axes		Total inertia	F-ratio	P value
	1	2			
Frequency (Seasons | Sites)					
Eigenvalues	0.071	0.050	1.032	3.053	0.0020 ***
Sum of all canonical Eigenvalues	0.138				
Frequency (Sites | Seasons)					
Eigenvalues	0.248	0.111	1.032	5.816	0.0020 ***
Sum of all canonical Eigenvalues	0.609				

Table II. Summary of the partial CCA of the vegetation data for Relative frequency and environmental data for seasons and sites

Parameters and data	Axes		Total inertia	F-ratio	P value
	1	2			
Relative frequency (Seasons | Sites)					
Eigenvalues	0.071	0.050	1.032	3.053	0.0020 ***
Sum of all canonical Eigenvalues	0.138				
Relative frequency (Sites | Seasons)					
Eigenvalues	0.248	0.111	1.032	5.816	0.0020 ***
Sum of all canonical Eigenvalues	0.609				

1b).

The relative frequency of the medicinal plant species of this area also differed significantly during the all four seasons (P<0.001, eigen values, 0.071; Table II). The *pCCA* ordination biplot indicated that most species were more frequent during summer (group-I). Some species (group-II) were more frequent during autumn. Species of group-III were equally frequent during summer and spring and species of group-IV had relative frequency between summer, spring and winter (Fig. 2a). Species in group-V had relative frequency values equally distributed between summer and autumn.

The *pCCA* of relative frequency data for sites as environmental variables and seasons as co-variables revealed highly significant variations (P<0.001, eigen value 0.248; Table II). The results of this analysis revealed that most of the species (group-I) were found to be more frequent at Khoora. Some species (group-II) had higher RF values at Khabeki and Anga. Species as *Fagonia indica* and *W. coagulens* were closely associated with Jallar site. Species of group-III and IV were relatively more abundant at Knotti Garden and Dape Sharif, respectively. Species of group-VII had RF values equally between Khoora and Dape Sharif, whereas group-V and VIII were associated between Dape Sharif, Khoora and Knotti Garden. However, species of group-VI had RF values between Khoora, Anga, Khabeki and Knotti Garden (Fig. 2b).

DISCUSSION

Soone Valley is very rich in floral diversity, entailing a treasure of valuable plant species. However, most of the plant species are restricted to very small period of the year at selected sites due to scarcity of available water, nutrients and favorable temperature. In this study, most of the species were frequent during summer mainly due to the presence of suitable temperature, enough moisture and macronutrients (Skarpe, 1990; Zaman, 1997; Nanette *et al.*, 2007). Another reason can be that the elevated temperature enhances shrub production and reduces non-vascular plants (Chapin, 1995; Chapin & Gaius, 1996; Escosa *et al.*, 2000). It was followed by autumn mainly due to suitable temperature, rainfall and availability of nutrients. Association of few species with spring is mainly attributes to severe cold temperature and low water availability. Only trees and few shrubs had little association with winter as these shrubs and trees were found growing during all seasons. Similarly, most of the species were more frequent around Khabeki and Khoora due to their association with macronutrients and high field capacity (Ahmad *et al.*, 2008). Salt and drought tolerant species were associated around Jallar. Moisture loving and moderately moisture requiring species were associated with and equally between the Knotti Garden and Dape Sharif (Misbahuzzaman & Alam, 2006; Malik *et al*., 2007a; Malik *et al*., 2007b; Ahmad *et al.*, 2008).

Table III. Classification of some of the available medicinal plant species indigenous to Soone Valley

Species	Khabeki				Khoora				Dape Sharif				Anga				Knotty Garden				Jallar			
	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
Adiantum capillus-veneris	-	-	-	-	-	-	-	-	R	R	R	-	-	-	-	-	O	R	R	R	-	-	-	-
Buxus papillosa	-	-	-	-	F	O	O	R	-	-	-	-	O	R	R	R	R	R	R	R	-	-	-	-
Diclyptera bupleroid	O	-	O	O	-	-	-	-	O	-	R	R	-	-	-	-	O	-	O	O	-	-	-	-
Fagonia indica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R	R
Justicia adhatoda	F	O	F	F	A	F	F	O	O	F	F	O	O	O	F	O	F	O	O	O	F	F	O	F
Mentha longifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	R	O	-	-	-	-
Peganum harmala	O	-	O	O	O	-	F	O	O	-	O	R	O	-	F	O	-	-	R	R	O	O	O	R
Salvia virgata	F	-	F	O	O	-	O	R	R	-	R	R	O	O	R	O	R	-	R	-	F	-	O	R
Solanum incanum	O	R	R	R	R	R	R	R	O	R	R	R	O	-	O	O	R	R	R	R	R	R	R	R
S. surrettens	R	-	R	R	-	-	-	-	-	-	R	R	-	-	-	-	-	-	-	-	R	R	R	R
Sophora tementosa	R	-	-	-	O	R	O	O	R	-	O	R	-	-	O	-	-	-	-	-	-	-	-	-
Withania somnifera	R	-	-	R	-	-	-	-	R	-	R	R	O	-	O	R	R	R	R	R	-	-	R	-

A: Abundant; F: Frequent; O: Occasional; R: Rare; - : Absent; S_1: Autumn; S_2: Winter; S_3: Spring; S_4: Summer.

Fig. 1. Partial CCA ordination biplot showing the effect of seasons (a) and sites (b) on frequency of vegetation from Soone Valley of Salt Range

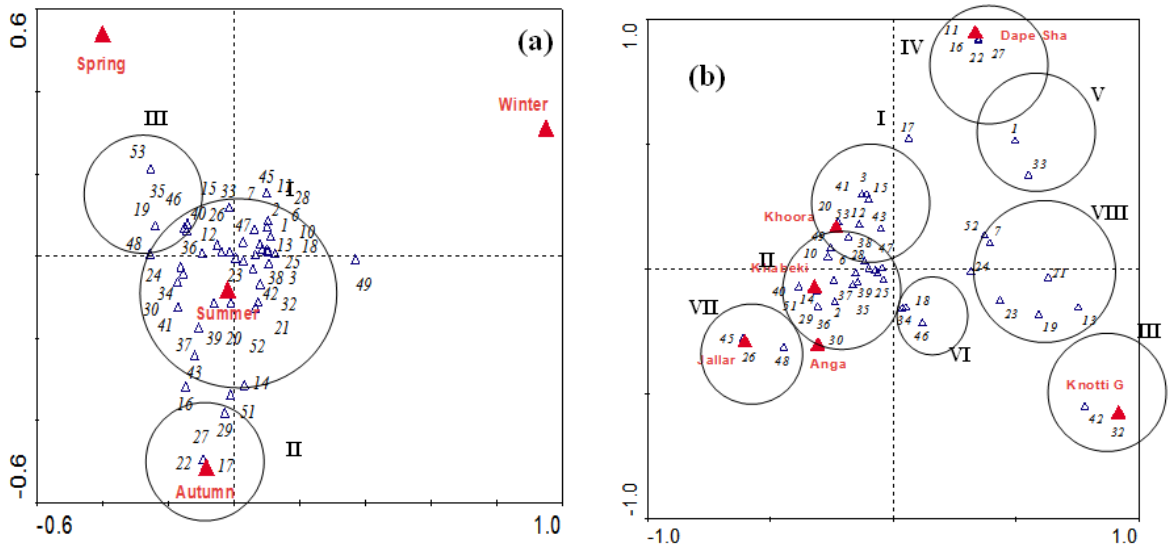
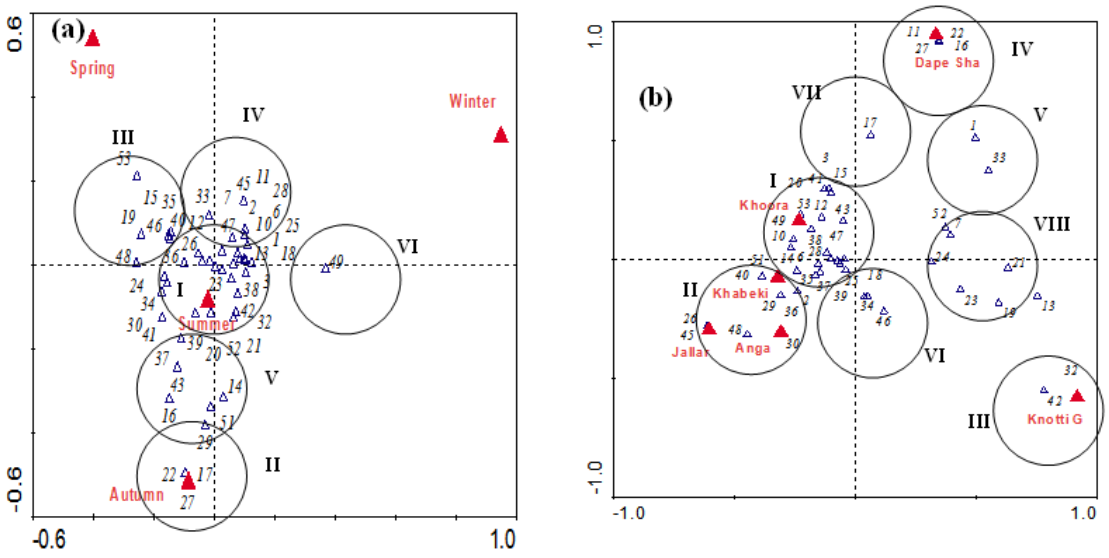


Fig. 2. Partial CCA ordination biplot showing the effect of seasons (a) and sites (b) on Relative frequency of vegetation from Soone Valley of Salt Range



Figures Leagend: 1. *Acacia farnesiana*; 2. *A. modesta*; 3. *A. nilotica*; 4 . *Albizia lebbeck*; 5. *Dalbergia sissoo*; 6. *Olea ferruginea*; 7. *Prosopis glandulosa*; 8. *Salvadora oleoides*; 9. *Tamarix aphylla*; 10. *Ziziphus nummularia*; 11. *Z. mauritiana*; 12. *Achyranthes aspera*; 13. *Adiantum capillus-veneris*; 14. *Alternanthera sessilis*; 15. *Sophora tementosa*; 16. *Barleria cristata*; 17. *Boerhavia procumbens*; 18. *Buxus papillosa* ; 19. *Cannabis sativa*; 20. *Capparis decidua*; 21. *Conyza ambigua*; 22. *Cynoglosum lanceolatum*; 23. *Datura metel*; 24. *Diclyptera bupleuroide*; 25. *Dodonea vasica*; 26. *Fagonia indica;* 27. *Heliotropium strigosum*; 28. *Justisia adhatoda*; 29. *Malvastrum coromandelianum*; 30. *Melilotus indica*; 31. *Medicago denticulate*; 32. *Mentha longifolia*; 33. *Nerium oleander*; 34. *Oxalis stricta*; 35. *Peganum hermala*; 36. *Salvia vergata*; 37. *Sida cordifolia*; 38. *Solanum incanum*; 39. *S. nigrum*; 40. *S. surretens*; 41. *Tecomela undulate;* 42. *Tenospora malabarica;* 43. *Trebulus terrustis;* 44. *Vicia sativa*; 45. *Withania coagulens*; 46. *W. somnifera*; 47. *Cynodon dactylon*; 48. *Cyprus niveus*; 49. *Saccharrum munja*; 50. *S. spontaneum;* 51. *Parthenium procumbens*; 52. *Desmostacya bipinnata;* 53. *Veronica arvensis.*

The spatial variations might be due to the soil type and its composition, elevation of sites, moisture contents of soil, nature of disturbance like grazing pressure, human interference and isolation of study site populated regions (Alhassan *et al.*, 2006). From the results it can be concluded that among medicinal plants, *J. adhatoda* was the most abundant species in the Soone Valley that might be due to its adaptations to various types of environments and greater

capability of osmotic adjustment. This species was successful in maintaining its high diversity that might also be due to strong root system, which may facilitate absorption of moisture as well as nutrients from in different type of soils (Ahmed, 2002; Hussain, 2002).

In the present study the observed medicinal plant species were classified according to their frequency ranges at different sites and during different seasons (Table III). *J. adhatoda* was the only very frequent medicinal plant during most of the seasons and at most of the sites. Other species were very much restricted to a particular season or a site as *P. harmala* was frequent during spring at Khoora and Anga, where as *Salvia virgata* was frequent at other sites. Most of the other medicinal plant species were only occasional or rare species of this region (Table III). The criteria of classification set in the present study were strongly supported by Dyksterhuis (1949) and Hanson (1951).

It can be concluded that species diversity in Soone Valley is dependent mainly on rainfalls, nutrient availability and particularly suitable temperature during summer. Similarly sites with better nutritional status and high moisture retaining capacity showed more diversity of plant species.

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