Chemical and genetic diversity among some wild stands of *Calligonum polygonoides* (Polygonaceae) from the Thar Desert of Rajasthan

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Abstract: The arid Western Rajasthan, where the Thar Desert of India is immersed, is mostly covered by sand dunes, a common landscape. The region has confronted with fragilities of natural resources, low, erratic and ill-distributed rainfall, and is covered up with many perennial hardy shrubs. *Calligonum polygonoides,* the most common perennial shrub, is widely present in some localities of this Thar Desert. In this study, we evaluated the diversity present among 54 wild *Calligonum polygonoides* plants, sampled from eight different locations within the Thar Desert. Our methods included chemical/nutritional characteristics and random amplified polymorphic DNA (RAPD). Both chemical and molecular methods produced wider range of diversity, however, RAPD detected comparatively more diversity. A total of 163 band positions were produced by ten RAPD primers, of which 147 were found polymorphic with 90.18% polymorphism. RAPD-based Jaccard's similarity coefficients ranged from 0.43-0.89. The analysis of various chemical and mineral constituents revealed that phog is an excellent source of calcium, potassium and phosphorous while relatively poor in zinc. Among minerals, average potassium content was found maximum (2 430mg/100g) with 0.14 CV. Zinc was observed comparably less in quantity while highest variable with CV 0.73. The chemical-based Manhattan dissimilarity coefficient values ranged from 0.01-0.22 with an average of 0.12. The comparison of the clusters obtained based on the chemical and mineral parameters with those of the RAPD data showed that the groups formed in both cases showed different patterns of relationships among the samples. Broader range of diversity might be due to the out breeding behavior of *C. polygonoides* and indicates the good adaptability of the plants in the region studied. However, low diversity observed in the Bikaner province is alarming and suggests that anthropogenic activities leading to heavy population disturbances can affect the genetic composition of the species in a considerable way. Rev. Biol. Trop. 60 (3): 1097-1108. Epub 2012 September 01.

Key words: chemical diversity, RAPD, nutritional parameters, *Calligonum polygonoides*.

Phog (*Calligonum polygonoides* L.), a xeric under-utilized shrub of Polygonaceae, dominantly found in arid and semi-arid region of Thar Desert and offer green advantage to desert in extreme adverse climatic conditions. The *Calligonum* genus includes more than 80 species with xeromorphic shrubby characteristics distributed throughout Southern Europe, North Africa and Western and Central Asia as its main biodiversity center (Brandbyge 1993). Of the 80 species of this genus, only *C. polygonoides* L. occurs in Indian arid zone. Historically, it was the dominant woody shrub of sand dune and sandy plain of the

Indian desert (Khan 1997). It is a slow growing, branching shrub, 1-2m in height with very deep penetrating roots, rarely growing up to 7m. Stems are modified into phylloclades and leaves are reduced, few or none, linear sublet; flowers are light pink, sweet-scented in axillary fascicles; nuts are oblong, densely clothed with reddish brown bristles (Pullaiah 2006). Being leafless, it is perfectly adapted to harsh conditions of Thar Desert (Rajpurohit *et al.* 1979). It has a massive network of underground root which works as effective 'sand binder' and thus preventing erosion and stabilizing sand dunes. It grows well in absence of any type of vegetation and dominant biomass producer of the sandy areas of the desert (Singh & Shankarnarayan 1986).

C. polygonoides has emerged one of the economically beneficial plants during last few years of continuous drought conditions in Western Rajasthan. The thick branching stem and roots are used as fuel for industries while buds are picked in food scarce during famines in arid regions. Flower buds are effective in treating sunstroke (Singh *et al.* 1996) and the aqueous paste of plant acts as an antidote against the heavy doses of opium and also against poisonous effects of certain harmful plants (Singh *et al.* 1996). The decoction of roots mixed with catechu is used as gargle for sour gums. It is consumed in dried form especially with curd based preparation (Goyal & Sharma 2008) and the only sources of food for desert animals in extreme drought conditions. Flower and small succulent fruits are eaten with buttermilk and salt in Western Rajasthan. During the hot season, the bushes are covered with the fragrant pinkish and protein rich flowers which after falling are swept up by the country people and eaten cooked.

The plant has been quoted in Red Data Book of IUCN as endangered plant species due to its large scale exploitation (Singh 2004). Phog (*C. polygonoides*) and khejri (*Prosopis cineraria*) from Thar Desert of Rajasthan, are the most popular fuel due to less smoke and good burning quality. These species are, therefore, over-exploited. A study published by CAZRI, Highlights of Research (2002) in sample villages of Bikaner district revealed an average fuel wood consumption of 15kg/day/family. The removal of *Calligonum* species from sandy terrain for growing dryland cash crops, e.g. *Arachis hypogea* is also a major threat to this species, which needs protection and propagation (Singh 2004). Increasing trend of well irrigation in some parts of desert is another reason of its eradication to prepare the soil for cultivation. Consequent upon over exploitation, wild stands of phog have reduced dramatically and there is a strong need for conservation of ecosystems for economic well being of people.

The plant has not yet drawn the attention for its systematic study and no efforts have been made except a cytological study by Valovich & Soskov (1973), who proposed 2n=54 as somatic chromosome number. However, some initial efforts have been made towards diversity analysis in *C. polygonoides* using isozyme (Tao & Ren 2004) and random amplification of polymorphic DNA (RAPD) (Ren *et al.* 2002, Bewal *et al.* 2009). In order to develop a systematic strategy for collection of representative sample covering large part of the variability and re-establish them in the area needs information regarding existing diversity for nutritional parameters as well as at molecular level. In present investigation, attempts have therefore been made to assess diversity at molecular and chemical level in *C. polygonoides*. For genetic diversity estimation, RAPD was selected due to the unavailability of specific markers, e.g. simple sequence repeat markers (SSRs) for the species under study. Moreover, RAPD is simple and most widely used to analyze diversity and genetic structure of wild plant species (Xu *et al.* 2003, Zhang *et al.* 2005, Vyas *et al.* 2009, Bewal *et al.* 2009).

MATERIALS AND METHODS

Study species and site: *Calligonum polygonoides* L., a dominant species of Thar Desert of Rajasthan was selected for the study (Fig. 1). This desert forms the Eastern

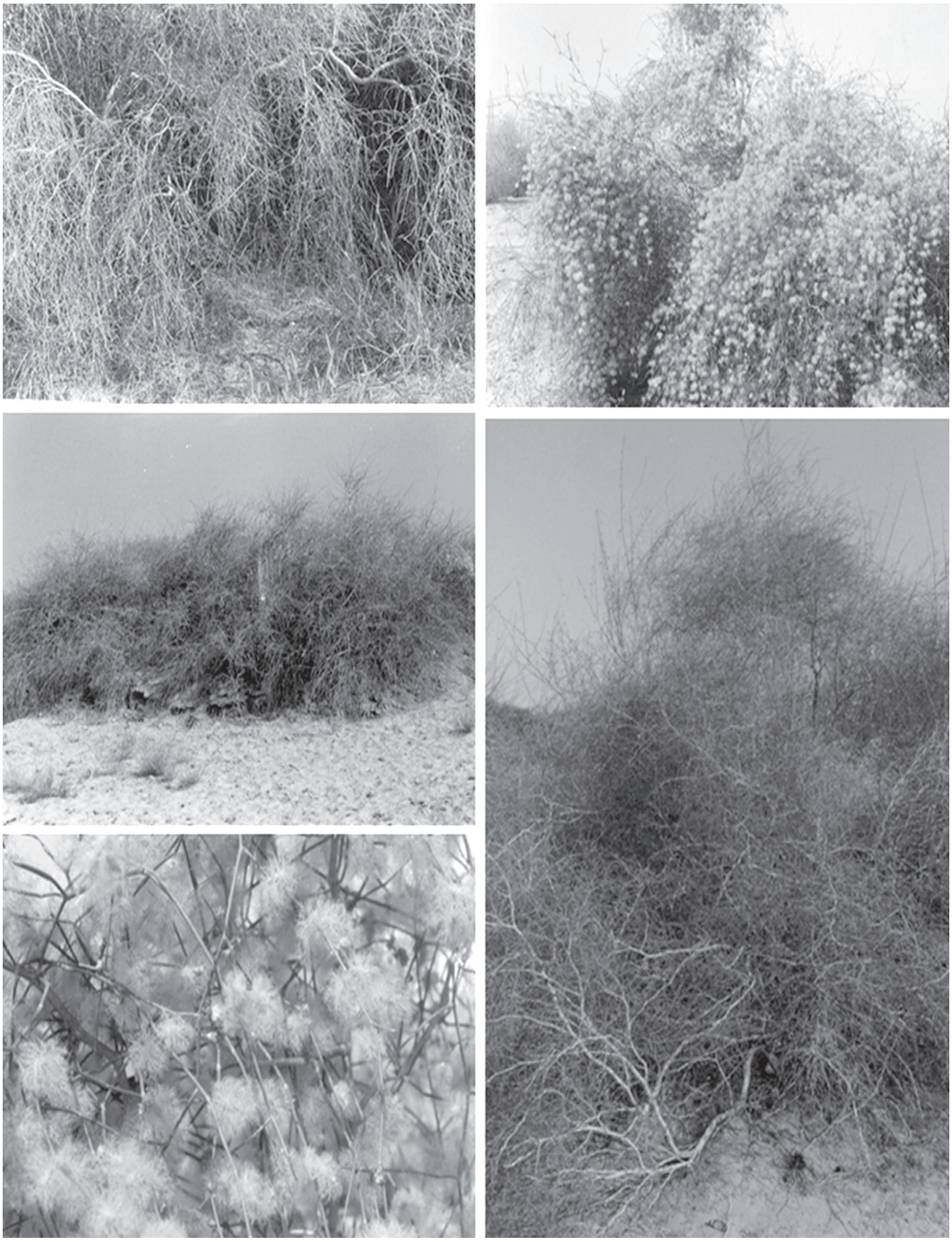

Fig. 1. Wild stands of *Calligonum polygonoides* with or without flowers.

extremity of the great arid and semi-arid belt of the world. It is one of the smallest deserts of the world but exhibits a wide variety of habitats and a high biodiversity, due to the juxtaposition of Palaearctic, Oriental and Saharan elements (Blanford 1901, Prakash 1963). In this study, 54 *C. polygonoides* plant samples were collected from eight locations of Thar Desert of Rajasthan. Most of the locations are located around 100km area from Bikaner except Churu zone of the study which was sampled from 165km apart of the Bikaner region. The ecological factors and soil characteristics for the collection sites are presented in table 1. The plants were tagged and their tender sprouts were collected in ice for DNA isolation while for chemical analysis, immature buds from two year old plants were collected.

RAPD analysis: Genomic DNA was isolated from tender twigs of each plant using the method of Doyle & Doyle (1990). After purification, DNA was quantified using Nano Drop spectrophotometer (ND-1000, Version 3.1.1, USA) and finally diluted to 25ng/µL for PCR analysis. A total of 10 RAPD primers of OPD and OPH series obtained from 'OPERON TECHNOLOGIES' (Inc. Alameda, California) were used for analysis. The PCR reactions were performed in a 25µL reaction mixture containing 1X assay buffer (100mM Tris pH 9.0, 500mM KCl, 15mM $MgCl_2$ and 0.1% gelatin), one unit of Taq DNA polymerase, 200µM of each dNTPs (Bangalore Genei Pvt. Ltd., India), 0.2µM primers and 50ng of template DNA. The PCR reactions were carried out in DNA thermal cycler (Model-CGI-96, Corbett Research, Australia) using the PCR profile: initial extended step of denaturation at 94°C for 4min followed by 44 cycles of denaturation at 94°C for 1min, primer annealing at 37°C for 1min and elongation at 72°C for 2min followed by a final step of extension at 72°C for 4min. The RAPD-PCR products were fractionated on 1.5% agarose loaded with EcoRI/HindIII digest λ DNA, containing 0.5µg/µL ethidium bromide. Gels were electrophoresed until the indicator dye reached 10cm from the well at 55mA. After separation gels were documented using Biovis Image Plus software (Expert Vision Pvt. Ltd. Mumbai).

Analysis of chemical parameters: The following chemical parameters i.e. moisture, crude protein, proline, total carbohydrate, starch, soluble sugar, crude fat, crude fiber, neutral detergent fiber (NDF), hemicellulose, cellulose and lignin were studied. The mineral composition of phog buds was studied for phosphorous, magnesium, iron, zinc, potassium and calcium. The moisture content, proline and soluble sugar/starch were estimated using the procedures given in/by ICMR (1983), Bates *et al.* (1973), Dubois *et al.* (1951), respectively. Fat content, crude fiber, crude protein, total carbohydrate, calcium, potassium, phosphorous, and dietary fiber (hemicellulose, cellulose and

TABLE 1
The ecological factors and soil characteristics of eight locations in the study

Province	Number of samples	Collection area (km)	Latitude	Longitude	Soil characteristics			
					pH	Average Organic Carbon (%)	Average Phosphate (kg/ha)	Average Potash (kg/ha)
Bikaner	9	2.0	28° 01' N	73° 22' E	7.2	0.09	58	250
Norangdesar	7	1.5	28° 05' N	73° 31' E	7.0	0.15	33	238
Pugal	6	1.0	28° 30' N	72° 48' E	7.3	0.17	42	425
Dhantor	8	1.5	28° 70' N	72° 59' E	7.6	0.16	27	500
Churu	6	1.0	28° 19' N	75° 01' E	7.5	0.11	42	400
Gorabdesar	5	1.0	28° 04' N	73° 28' E	7.8	0.12	40	380
Lunkaransar	8	1.5	28° 29' N	73° 44' E	7.0	0.15	26	409
Hardesar	5	1.0	28° 03' N	74° 70' E	6.9	0.09	24	310

lignin) were determined according to AOAC (1995). Magnesium, iron and zinc were analyzed by using Atomic Absorption Spectrophotometer (Model: GBC-932 AA).

The RAPD bands were scored as binary matrix for the presence (1) or absence (0). All calculations were done using computer program NTSYSpc v. 2.02 (Rohlf 1998). Similarity matrix was constructed using the Jaccard's coefficients and subjected to Unweighted Pair-Group Method with Arithmetic Averages (UPGMA) analysis, to generate dendrogram. In case of chemical parameters, Manhattan distance coefficients were used to generate dissimilarity matrix which was subjected to UPGMA analysis to generate dendrogram after the standardization of observations. The matrices derived from RAPD and chemical data were correlated using MxComp module of NTSYSpc. In both dendrograms, average coefficient was used as cut-off value to define clusters. The discriminatory power (Dj) of RAPD primers was analyzed using the standard statistical package of Tessier *et al.* (1999). Polymorphism information content (PIC) was also calculated according to Anderson *et al.* (1993). Arithmetic mean, standard deviation and coefficient of variation (CV) were calculated for each trait using standard formula given in Chandel (1997).

RESULTS

RAPD analysis: A total 163 (16.3 bands per primer) RAPD markers were generated by 10 primers for 54 individual samples of *C. polygonoides.* Out of 163 RAPD markers, 147 were recorded as polymorphic with 90.18% polymorphism**.** Maximum number of polymorphic bands (66.26%) were recorded in samples collected from Dhantor region, while minimum (37.42%) from Bikaner region. Most of the scorable band positions ranged from 300bp-4000bp. Primer efficiency was calculated using polymorphism information content (PIC) (Anderson *et al.* 1993) and discrimination power (Dj). The average PIC values for RAPD primers ranged from 0.26 (OPD-12) - 0.44 (OPH-19). Discriminatory power (Dj) for all the RAPD primers ranged from 0.93-1.0. The RAPD primer, OPH-13 and OPH-19 found maximum polymorphic (100%) and discriminatory (1.0) compared to other RAPD primers (Table 2). RAPD-based Jaccard's similarity coefficients ranged from 0.43-0.89 with a mean genetic similarity of 0.49. UPGMA based dendrogram clustered all the phog samples into seven groups (Fig. 2A). Average similarity coefficient (0.49) was used as cut-off value to classify the dendrogram. Most of the samples from Bikaner and Norangdesar regions were

TABLE 2
Primer sequences, total bands, polymorphic bands and other parameters of RAPD primers

Primers	Sequences (5'®3')	Ta	Tb	% P	Dj	PIC
OPD-11	AGCGCCATTG	14	13	92.85	0.99	0.27
OPD-12	CACCGTATCC	15	12	80.00	0.93	0.26
OPD-20	ACCCGGTCAC	20	19	95.00	0.97	0.38
OPH-03	AGACGTCCAC	10	08	80.00	0.97	0.41
OPH-05	AGTCCTCCCC	27	24	88.88	0.99	0.37
OPH-12	ACGCGCATGT	16	14	87.5	0.97	0.38
OPH-13	GACGCCACAC	19	19	100	1.0	0.42
OPH-19	CTGACCAGCC	11	11	100	1.0	0.44
OPH-20	GGGAGACATC	17	14	82.35	0.99	0.38
OPH-21	ACTCCGCAGT	14	13	92.85	0.95	0.43
Total		163	147	90.18	--	--

Ta=total number of bands, Tb=polymorphic bands, %P=% polymorphism, Dj=discrimination power, PIC=polymorphism information content.

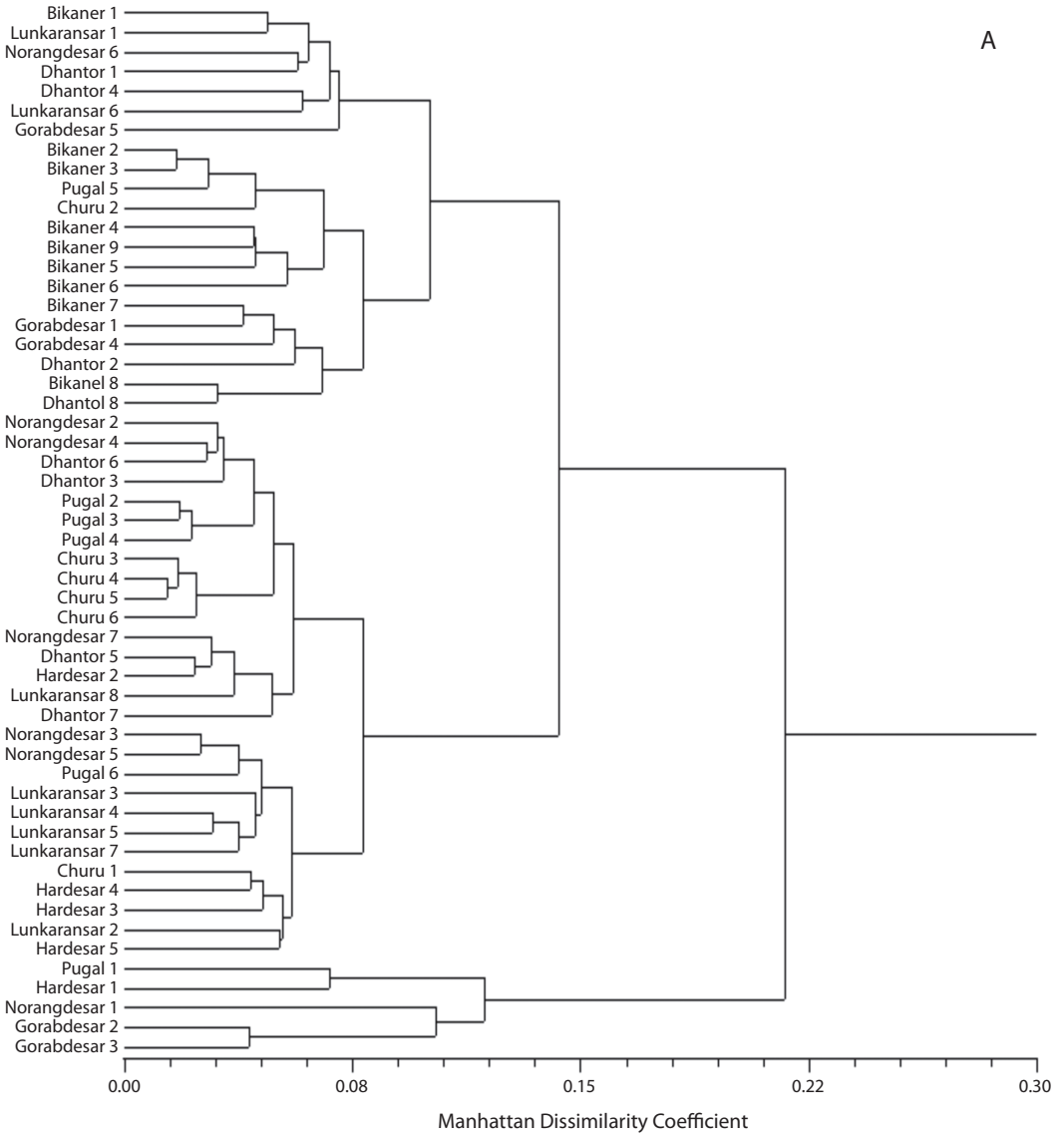

Fig. 2A. Dendrogram derived from UPGMA cluster analysis using **(A)** Jaccard's similarity coefficient based on RAPD markers.

clustered into uppermost group of the dendrogram. However, samples of Bikaner province were sub-grouped with high similarity. Most of the clustering was found independent of the geographical region.

Chemical analysis: All the chemical parameters with minimum, maximum, mean and CV values are presented in table 3. All the minerals were observed in the following order of decreasing quantity i.e. K>Ca>P>Mg>Fe>Zn. Average potassium content was found highest (2 430mg/100g DW) in *C. polygonoides* buds with 0.14 CV. Highest content variation (CV 0.73) was observed for Zn followed by Fe (CV 0.50), while it was observed mninimum

TABLE 3
Statistical analysis of different chemical parameter for 54 phog samples

	Moisture (%)	Crude protein (%)	Proline (mg/100g)	Total Carbohydrate (%)	Soluble Sugar (%)	Starch (%)	Crude fiber (%)	NDF (%)	Hemicellulose (%)	Cellulose (%)	Lignin (%)	Crude fat (%)	Fe (mg/100g)	Zn (mg/100g)	K (%)	Phosphorus (mg/100g)	Mg (mg/100g)	Ca (%)
Max	68.49	21.95	13.31	76.64	26.1	25.5	14.6	42.9	15.96	14.82	12.43	4.91	17.9	3.8	3.54	319.9	58.94	3.92
Min	50.32	15.26	8.06	67.12	10.73	11.07	8.4	24.03	6.19	6.45	6.2	2.22	1.12	0.06	1.63	115.4	39.06	1.09
Mean	61.44	18.66	10.46	72.39	17.91	19.11	10.91	32.28	11.81	10.64	9.02	3.26	7.88	1.62	2.43	216.5	49.08	2.28
SD	3.56	1.64	1.49	2.18	4.39	3.51	1.42	5.26	2.62	2.2	1.92	0.94	3.99	1.18	0.36	61.04	5.83	0.63
CV	5.79	8.82	0.14	3.01	0.24	0.18	0.13	0.16	0.22	0.2	0.21	0.28	0.5	0.73	0.14	0.28	0.1	0.27

Max=maximum, Min=minimum, SD=standard deviation, CV=coeffecient of variation.

(CV 0.10) for magnesium content. The samples of Dhantor and Hardesar province were found comparatively rich in Zn content with average values, 2 252mg/100g (DW) and 2 592mg/100g (DW), respectively. Phog buds were also found rich in calcium content with highest (3 920mg/100g DW) and lowest (1 090mg/100g DW) quantities (Table 3).

The moisture content varied from 50.32-68.49 % with mean value 61.44±3.56%. The crude fiber was found to be 10.91±3.51%. The total carbohydrate was main constituent of the buds, ranged between 67.12-76.64%, averaged 72.39±2.18%. The NDF ranged from 24.03-42.90 with mean value 32.28±5.26%. Starch and soluble sugar were present in approximately same quantity with mean value 19.11±3.51% and 17.91±4.39% respectively. The hemicellulose, cellulose and lignin were present with the mean value of 11.81±2.62%, 10.64±2.2% and 9.02±1.92%, respectively.

The crude fat in phog buds ranged from 2.22-4.9% with a mean value of 3.35±0.94%. The mean quantity of free proline was observed 8.06±1.49mg/100g. Crude proteins ranged from 15.26-21.95% with the mean value 18.66±1.64%. Most of the chemical parameters were negatively correlated to each other, however, structural components like NDF, hemicelluloses, cellulose, lignin, crude fiber found positively correlated to each other. Significant positive correlations (>0.5) were reported between cellulose and lignin (0.56), calcium and potassium (0.51), NDF and lignin (0.70), NDF and hemi cellulose (0.77), and NDF and cellulose (0.49).

Chemical parameters based diversity analysis: The Manhattan dissimilarity coefficients ranged from 0.01-0.22 with an average of 0.12. Average dissimilarity coefficient within region ranged from 0.13 (within Dhantor) to 0.17 (within Norangdesar). Mean chemical dissimilarity was found minimum (0.08) among samples of Bikaner region followed by Churu and Lunkaransar (0.09) regions, however, it was found maximum (0.16) in samples of Norangdesar region followed by Gorabdesar (0.15) region. The UPGMA-based dendrogram has clearly put all the samples in three major groups at average similarity coefficient (0.12) as cut-off value. Group I was clustered with 21 samples at 0.10 dissimilarity coefficient while group II clumped with 28 samples at 0.08 coefficient value. Group III contained only five phog samples with maximum dissimilarity (Fig. 2B). The first group comprised all the samples from province of Bikaner while most of the samples from province of Churu were aggregated in group II. The remaining samples distributed throughout the dendrogram. Norangdesar and

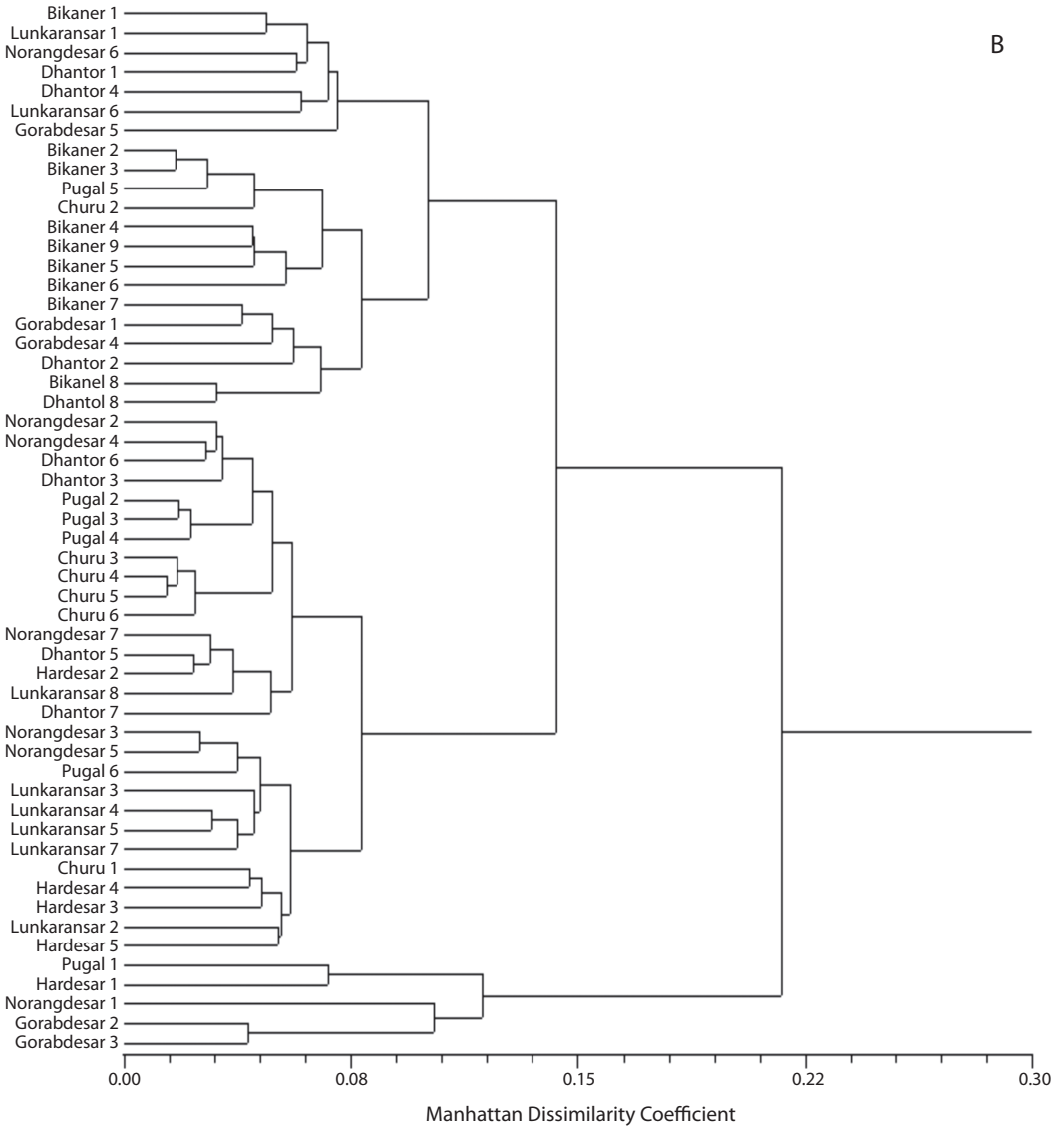

Fig. 2B. Dendrogram derived from UPGMA cluster analysis using **(B)** Manhattan dissimilarity coefficient of chemical parameters.

Gorabdesar samples were distributed randomly in the chemical-based dendrogram due to high dissimilarity coefficient.

DISCUSSION

In present study, an effort was made to find out current ecological behavior of *C. polygonoides* species in Thar Desert of Rajasthan, by analyzing its chemical/nutritional and genetic diversity. Using RAPD analysis a very great range of diversity was obtained among 54 wild *C. polygonoides* samples of eight different provinces of Rajasthan. In the study, 10 RAPD primers produced a very good range of discriminatory power and PIC values.

All the RAPD primers used were found informative as the Dj value ranged from 0.93-1.0. A very high range of discriminatory power indicates that all the RAPD primers generated distinct patterns for all the phog samples with great diversity. A low mean genetic similarity (0.49) among *C. polygonoides* samples reflects diverse gene pool, able to withstand in harsh environmental conditions.

At nutritional level, *C. polygonoides* is an excellent source of calcium, potassium and phosphorous while relatively poor in zinc. Nutritionally all the *C. polygonoides* samples were found rich in nutritional compounds. Plants with sufficient minerals are found to be more drought resistant (Bouis 1996) and this factor might be supportive in phog against drought. The moisture content of *C. polygonoides* plants was detected less (50.32-61.44%) in comparison to *Capparis deciduas* (74.2-84.6%), another wild plant from the same province (Vyas *et al.* 2009). The low moisture content indicates adaptability and hardiness of *C. polygonoides* plant in adverse conditions of the desert area and ability to survive in desert without water supply for years.

The crude fiber, crude protein and total carbohydrate were found comparable with other plant species such as legumes (Olaofe *et al.* 1994), ker (Vyas *et al.* 2009) and specifically with *C. polygonoides* (Singh *et al.* 2005). There is evidence that crude fiber has a number of beneficial effects related to its indigestibility in the small intestine (Aremu *et al.* 2006). The mean proline content was found maximum in samples of Lunkaransar province followed by Churu province. The NDF contributed maximum to the total carbohydrate and hemicellulose, cellulose and lignin contributed to NDF in decreasing order with the mean value of 11.81±2.01%, 10.64±1.76% and 9.02±1.47%, respectively which was corollary to the contents reported in other plant species by Agarwal & Chauhan (1988), Vyas *et al.* (2009). The co-similarity of chemical parameters in same as well different desert plant species might provide hardiness and adaptability to these plants in xeric conditions.

Comparative statements of chemical and RAPD-based diversity: In RAPD analysis, high level of genetic diversity was found among *C. polygonoides* samples, where near 90.18% RAPD markers were polymorphic. However, the RAPD patterns were not found systematic in respect to classification of samples accords to regions which leads to an uncharacterized diversity in dendrogram. DNA-based diversity was found high in comparison to chemical-based diversity. However, within region diversity was lesser in most of the cases compared to between region diversity in both of RAPD and chemical parameters. But, wherever between regions diversity was comparable or less to within region diversity the places were mostly closely associated and represented same gene pool. All the *C. polygonoides* samples were clustered into seven groups on the basis of Jaccard's coefficient. The RAPD-based dendrogram generated poor groups because within group similarity was comparable to between group similarities. The present study revealed a very low correlation (r0.01) between chemical- and RAPD-based matrices, indicates that the two methods were different and highly variable. Therefore, RAPD-based data are not useful for estimating the chemical characteristics of *C. polygonoides* samples. Krofta *et al.* (1998), Patzak *et al.* (2010) also found difference between molecular and chemical data of wild hops (*Humulus lupulus*). High similarity in chemical parameters proposes least variable expression of the genes for these chemical parameters in extreme drought conditions.

Low level of diversity generated by chemical parameters compared to RAPD suggesting better efficiency of the RAPD profiles for diversity analysis that account unexpressed DNA sequences as well genes contributing structurally and functionally and not confounded by environmental factors (Henry 1997). A low averaged genetic similarity (0.49) in case of RAPD, indicating wide adaptability of the *C. polygonoides* in the studied region. The evolution of wild *C. polygonoides* samples in distinct climatic zones demonstrates significant levels of variations in response to the

selection pressure in their native environment (Singh *et al.* 1996). It is therefore not surprising to find significant levels of polymorphism among 54 *C. polygonoides* samples as revealed by RAPD markers and chemical parameters. High level of genetic diversity and no structure of RAPD-based dendrogram accords to locations were found comparable with previous study of Bewal *et al.* (2009). Diversification of *C. polygonoides* samples from same region into different clusters indicating frequent seed dispersal or other way of propagation from long distances as high velocity winds are characteristics of these regions. Samples from Bikaner region showed highest average genetic similarity (0.75) on the basis of Jaccard's coefficient while average minimum genetic similarity (0.50) was observed in the samples of Gorabdesar region. The low diversity in the samples from Bikaner province might be due to the anthropogenic activities leading to heavy population disturbances which can affect the genetic composition of the species considerably. Anthropogenic activities therefore appear to be potential threats for the loss of genetic information particularly in spatially isolated small populations.

The *C. polygonoides* cross pollinates (anemophily) (Raju *et al.* 2001) which might lead to high variations at chemical as well as molecular levels, not withstanding the fact that the populations of the species under study are located at tens to hundreds of kilometers of distance. Predominantly obligate out breeding behavior of *C. polygonoides* beside certain non-comprehensible reasons prompted these accessions to spread and occupy specific geographical niches thereby enhancing their adaptational capabilities vis-à-vis native climatic conditions. Nevertheless the present study is a first attempt to define the existing natural genetic diversity based on chemical parameters and genomic level, among the populations of *C. polygonoides,* collected from different locations of Thar Desert of Rajasthan (India).

Despite having such a great level of biodiversity characterized by RAPD and chemical parameters, *C. polygonoides* is included in Red Data Book of IUCN under near extinct plant category. Very low rain fall, high wind velocity, erosion of deserts, exploitation of shrubs for fuel purposes and consecutive grazing of plants by desert animals are some reasons might influence its proper growth and development. Plants have tremendous ability of growth and reproduction in adverse conditions of deserts but low and low rainfall since a few years is alarming for its survival and special attention is needed to preserve the biodiversity and its rehabilitation. The characterized chemical parameters indicating high nutritional value of wild stands of *C. polygonoides*, making it an important local forage plant. Samples from Norangdesar, Pugal and Churu were found very rich in phosphorus content while samples from the province of Bikaner were found rich in iron content. Nutritionally rich *C. polygonoides* plants might be added to fortify nutritionally deficient foods of desert areas.

A study on genetic diversity of *C. polygonoides* in the Thar Desert is prerequisite to reveal the ecological and genetic consequences and to preserve the biodiversity, while an analysis for chemical parameters would help in selection of plants with higher nutritional values. Moreover, the combined information will reflect applicability of molecular markers in assessing diversity at chemical level. The results of nutritional and DNA polymorphism could provide information regarding genetic background and distribution of diversity of *C. polygonoides* and further help to plan an effective conservation strategy for the species.

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RESUMEN

El árido Rajastán occidental, en donde está inmerso el desierto de Thar en la India, está cubierto principalmente

por dunas de arena, un paisaje común. La región ha enfrentado la fragilidad de los recursos naturales, las lluvias escasas, irregulares y mala distribución, y está cubierta con muchos arbustos resistentes perennes. *Calligonum polygonoides*, el arbusto perenne más común, se encuentra ampliamente en algunas localidades del desierto de Thar. En este estudio, se evaluó la diversidad presente entre 54 plantas silvestres de *Calligonum polygonoides*, de ocho localidades diferentes del desierto de Thar. Nuestros métodos incluyen características químicas/nutricionales y ADN polimórfico amplificado (RAPD) al azar. Ambos métodos químicos y moleculares producen un amplio rango de la diversidad, sin embargo, RAPD detectó comparativamente mayor diversidad. Un total de 163 posiciones de la banda fueron producidos por diez cebadores RAPD, de los cuales 147 se encontraron polimórficos con un 90.18% de polimorfismo. El coeficiente de RAPD basado en la similitud de Jaccard varió desde 0.43 hasta 0.89. El análisis de varios constituyentes químicos y minerales reveló que *Calligonum polygonoides* es una excelente fuente de calcio, potasio y fósforo mientras que es relativamente pobre en zinc. Entre los minerales, el contenido de potasio promedio se encontró como máximo (2 430mg/100g), con 0.14 CV. El zinc se observó comparativamente menor en cantidad, pero presentó la mayor variabilidad con CV 0.73. El valor del coefficente de disimilitud de Manhattan varió en un rango de 0.01 hasta 0.22 con un promedio de 0.12. La comparación de los grupos obtenidos según los parámetros químicos y minerales con las de los datos de RAPD mostró que los grupos formados en ambos casos mostraron patrones diferentes de relaciones entre las muestras. Una gama más amplia de la diversidad podría ser debido al comportamiento reproductivo *C polygonoides* e indica la buena adaptabilidad de las plantas en la región estudiada. Sin embargo, la baja diversidad observada en la provincia de Bikaner es alarmante, y sugiere que las actividades antropogénicas que conducen a disturbios excesivos en la población pueden afectar la composición genética de la especie de una manera considerable.

Palabras clave: diversidad química, RAPD, parámetros nutricionales, *Calligonum polygonoides*.

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