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Evaluating the Agro-morphological Variation in *Panicum antidotale* in Cholistan Desert, Pakistan

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ABSTRACT

The present study was conducted to examine the pattern of genetic diversity through agro-morphological characters in various accessions of *Panicum antidotale* Retz. collected wild from various habitats of Cholistan desert. Descriptive statistics, correlation among characters and Principal Component Analysis (PCA) applied on the data that showed great morphological variations among the accessions. The pattern of morphological diversity suggested that the accessions represent a relict population with recency in habitat loss. The characters such as plant height, number of tillers and high tillering capacity serve as agronomic, as well as morphological descriptors of the prevailing genetic diversity and this variation encountered, had a genetic basis. Different morpho-types adapted themselves by developing different associations with other plant species and therefore acquire active refuge both from severe environmental conditions and grazers. Based on the present study, it is documented that the immediate need of an *ex situ* conservation with a representation of all six groups identified with PCA, in a provenance of several areas of Cholistan desert. The conservation efforts, therefore, could still preserve the relict genetic diversity. © 2010 Friends Science Publishers

Key Words: Genetic diversity; Conservation; Relict population; Accessions; Habitat loss

INTRODUCTION

Perennial grasses, palatable and nutritive, mostly serve as a significant source of fodder in arid environments (Haase *et al*., 1995; Mansoor *et al*., 2002). Perennial grasses naturally occur in Cholistan desert are *Aeluropis lagopoides*, *Cenchrus ciliaris*, *C. setigerus*, *Cymbopogon jawarancusa*, *Lasiurus scindicus*, *Ochthochloa compressa*, *Panicum antidotale*, *P. turgidum* and *Sporobolus iocladus* (Rao *et al*., 1989). The perennial grass species show a number of adaptations in dry environments, for example, the tussock growth form that enhances survival under stress conditions (Haase *et al*., 1995). With appropriate rainfall in the Cholistan desert (100-200 mm/annum), these grass species with other vegetation types provide upto 60% of vegetation covers (Akhter & Arshad, 2006). After producing large palatable herbage, lower portions of the tillers of grasses quickly become hard causing oral injury to the grazers, thus saving the stubbles for the future regeneration.

Panicum antidotale (locally called "Murrot" or "Bansi Ghrass") is a tall, erect, much branched and tussock forming grass (Rao & Arshad, 1991; Arshad, 1996). It grows on a variety of soils in Cholistan desert, yet fertile sandy loam suits well for optimum production (Rao *et al*., 1989). This species is an efficient sand-binder (Arshad, 1996) thus playing a role in stabilizing the sand dunes (Saini *et al*., 2007). In fact, *P. antidotale* along with *L. scindicus* was found to be the most drought resistant grass species in arid regions (Saini *et al*., 2007). It is a drought and salt resistant species with promising forage production (Arshad, 1996). Its nutritive value based on protein content (Gul-e-Rana *et al*., 1990; Saini *et al*., 2007) and its year round availability, makes an excellent source of fodder as hay or silage in the newly colonized areas of Cholistan desert. At the advent of monsoon, it is amongst the earliest to sprout. In spite of prolonged drought, individual plants of *P. antidotale* could be seen in sandy loam soils indicating its eco-physiological adaptations (Rao *et al*., 1989). However, the heavy grazing pressure has diminished stands of *P. antidotale* from the arid rangelands of Cholistan desert. This causes a shortage of fodder, consequently affecting livestock production in the area (Akhter & Arshad, 2006).

A number of studies have been carried out focusing on the adaptation and available genetic diversity of perennial grasses in their target environments. Theunissen (1997) studied various morphological characters and found

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phenotypic adaptations in *Digitaria eriantha* to severe environmental conditions in South Africa. Morpho-genetic variation was also reported among accessions of *C. jawarancusa* (Arshad *et al*., 1995), *S. iocladus* (Arshad *et al*., 1999), collected from the area. Tefera *et al*. (1992) calculated genetic correlations among quantitative characters of *Eragrostis tef* (Zuec.) and found 'panicle weight' to be closely associated with 'primary tiller', thus an increase in dry mass production. A study on genetic variability in perennial grasses depicted great deal of morphological variation in Cholistan desert (Rao *et al*., 1989). Other studies also highlighted the inherent genetic diversity in *C. ciliaris* (Arshad *et al*., 2007), *L. scindicus* (Arshad *et al*., 2009; Nisar *et al*., 2010) and *P. antidotale* (Sohail *et al*., 2010). These studies have shown high phenotypic diversity and variability among accessions collected from various habitats of Cholistan.

The primary objective of this study was to examine the pattern of genetic diversity through agro-morphological characters in the declining populations of *P. antidotale* to devise a conservational strategy for protecting the remaining genetic diversity and ultimately the species in the entire territory of Cholistan desert.

MATERIALS AND METHODS

The Cholistan desert (27 42 - 29 45 N^o & 69 52 - 75 94 E^o), a stretch of about 26,000 km^2 is one of the hottest deserts in Pakistan (Anon, 1993). Collection expeditions were made during March-April, 2007 to the area and accessions/stubbles of *P. antidotale* Retz. were sampled (Table I). Due to over grazing and prolonged droughts, plants and seeds were rarely available; therefore we sampled whatever plant stubbles encountered. Each stubble was then divided into five plantlets. Individual plantlets were raised and studied in the experimental fields at Quaid-i-Azam University, Islamabad, by maintaining 1 m distance between plantlets.

Eleven agro-morphological characters (Table II) using standard forage grass descriptors (Tyler *et al*., 1985) were studied from maturing plants. Plantlets from same accession were studied individually and their average values were tabulated. For each accession mean, range and standard deviations were calculated. Principal Component Analysis (PCA) (Anon, 1985) and correlation co-efficient (Tefera *et al*., 1992) were performed using Minitab for windows © (ver. 11.0).

RESULTS

In the present study we have calculated the mean, range and standard deviation for all morphological characters in accessions sampled from wild natural populations. Multiple plantlets for all accessions were raised under uniform environmental conditions; nonetheless, enormous morphological variation was observed. Maximum variation was found in 'plant height' (SD = 8.27) and in 'number of fertile branches per plant' (SD = 6.49). On the contrary, characters like 'internode covered by leaf sheath' (SD = 0.21), 'stem thickness' (SD = 0.26) and 'length of inflorescence' (SD = 0.48) have shown minimum variation. We correlated these patterns with the site data to understand the role of environmental conditions and the pattern of morphological variation. The collected data revealed that edaphology and vegetation type are different but topography and anthropogenic affects are somewhat same among sites (Table I) and found some diversity. The summary statistics for these characters has been presented in Table III. Data synthesis on plants originally collected from clayey soil revealed better height, more number of leaves and fewer spikelets compared to plants found in sandy or sandy loam having less tillers, more internodes, better flag leaf area and more number of spikelets.

We also studied pair wise correlations among morphological characters (Table IV). It was found that 'height of plant' was positively correlated with 'number of tillers' 'number of fertile branches' and 'stem thickness' depicting an overall vigor in plant size. Thus, with favourable environmental conditions, plants attained optimum height with increased stem thickness and demonstrated better tillering capacity. Conversely, 'height of the plant' was found negatively correlated with 'flag leaf area'. Characters such as 'number of leaves' 'length of inflorescence' and number of spikelets per inflorescence' did not show any correlation with 'plant height'. Among other characters 'number of spikelets per inflorescence' was found inversely correlated with 'number of nodes on main tiller'. Also 'number of leaves' was found positively associated with 'length of inflorescence'. 'Flag leaf area' did not show correlation with any of the characters except 'plant height'.

Principal Component Analysis (PCA) was performed to identify accession groups having diverse morphologies and suitable for *in situ* and *ex situ* conservation. The first three principal components cumulatively contributed 59.9%. Based on character loadings (at an absolute value > 0.4) on eigenvectors, characters contributing significantly have been identified (Table V). The 1st principal component accounted for 24.1% of the variation with eleven characters being major contributors. The components differentiated the accessions into six groups placing them along both sides of the axis (Fig. 1). The characters contributing most to this variation included 'length of inflorescence' and length of internode covered by leaf sheath'.

The 2nd and 3rd principal components accounted for 19.3% and 16.5% variation, respectively. Four characters 'number of tillers per plant' 'number of fertile branches per plant' 'number of internodes on main tiller' and 'thickness of stem' exhibited strong loadings. Individuals of *P. antidotale* situated on positive side along the x-axis (Group D & E) were characterized by 'thickness of stem', whereas group A, B and C situated on negative side of component 2

Table I: Accessions of *P. antidotale* along with their site name in Cholistan desert, Pakistan

Site Name	*Accession*	*Provenance*	*Vegetation*	*Soil Type*	*Topography*
Khokhran Wala Toba	KWT 1	28.892 ˚*N* 71.774 ˚*E*	Scrub & Heavily Grazed	Sandy loam	Dunes and humps
Khokhran Wala Toba	KWT 2	28.892 ˚*N* 71.774 ˚*E*			
Khokhran Wala Toba	KWT 3	28.892 ˚*N* 71.774 ˚*E*			
Moj Garh	MJ 1	29.016 ˚*N* 72.082 ˚*E*	Scrub (Sparse trees) &	Clayey	Flat plains
Moj Garh	MJ 2	29.016 ˚*N* 72.082 ˚*E*	Heavily Grazed		
Moj Garh	MJ 3	29.016 ˚*N* 72.082 ˚*E*			
Khiwtal Wala Toba	KhWT 1	28.362 ˚*N* 71.505 ˚*E*	Scrub (Sparse trees) &	Sandy	Flat plains
Khiwtal Wala Toba	KhWT 2	28.362 ˚*N* 71.505 ˚*E*	Heavily Grazed		
Khiwtal Wala Toba	KhWT 3	28.362 ˚*N* 71.505 ˚*E*			
Derawar Fort	DR 1	28.768 ˚*N* 71.333 ˚*E*	Sparse trees & Heavily	Clayey	Flat plains
Derawar Fort	DR 2	28.768 ˚*N* 71.333 ˚*E*	Grazed		
Derawar Fort	DR 3	28.768 ˚*N* 71.333 ˚*E*			
Lal Sohanra	LS 1	29.395 ˚*N* 71.998 ˚*E*	Large shrubs &	Sandy loam	Dunes and humps
Lal Sohanra	LS 2	29.395 ˚*N* 71.998 ˚*E*	Moderately grazed		
Lal Sohanra	LS 3	29.395 ˚*N* 71.998 ˚*E*			

Table II: Agro-morphological characters of *P. antidotale* used in the present study

Character	*Unit*
Height of the plant	cm
Number of tillers per plant	-
Number of fertile branches per plant	-
Number of leaves on main tiller	-
Length of inflorescence	cm
Number of internodes on main tiller	-
Flag leaf area	cm^2
4^{th} node leaf area of main tiller	cm^2
Length of internode covered by leaf sheath at 4^{th} node	cm
Thickness of stem at 4^{th} node of main tiller	mm
Number of spikelets per inflorescence	-

(Fig. 1) were characterized by having additional; 'number of tillers per plant', 'number of fertile branches per plant' and 'number of internodes on main tiller'.

Table III: Descriptive statistics of various quantitative characters in *P. antidotle* accessions collected from various parts of Cholistan desert, Pakistan

Character	*Range*		*Mean*	*SD*
	Min	**Max**		
Height of the plant (cm)	119.1	151.4	142.79	8.27
Number of tillers per plant	14.6	18.9	16.951	1.49
Number of fertile branches per plant	82.7	105.7	95.74	6.49
Number of leaves on main tiller	19.1	24.4	22.097	1.57
Length of inflorescence (cm)	17.9	19.5	18.795	0.48
Number of internodes on main tiller	9.3	11.1	10.231	0.52
Flag leaf area (cm^2)	6.2	8.4	7.494	0.59
4^{th} node leaf area of main tiller (cm^2)	7.0	12.3	10.968	1.26
Length of internode covered by leaf sheath at 4^{th} node (cm)	6.5	7.1	6.880	0.21
Thickness of stem at 4^{th} node of main tiller (mm)	3.9	4.9	4.463	0.26
Number of spikelets per inflorescence	15.7	18.2	17.25	0.72

DISCUSSION

P. antidotale populations in Cholistan desert has been on decline due to un-availability of moisture and heavy grazing pressure. The present study has practical implication as low frequency of this palatable grass species directly reduces the carrying capacity of arid rangelands of Cholistan (Arshad, 2006; Sohail *et al*., 2010). Morphological markers, under these circumstances seem to have reliably quantified the genetic diversity for the species residing in arid rangelands with unique set of environmental conditions. We assessed the phenotypic diversity of whatever accessions of *P. antidotale* found. Encountering only very few accessions further endorsed the need to study and conserve the genetic diversity of an economically important range species.

Field observations and patterns of morphological variation in accessions of *P. antidotale* suggested that only carefully selected characters might reveal true genetic grouping. However, this remained to be seen as to which characters might be a better option to predict the genetic grouping and the better adaptability of accessions under severe environmental conditions. The characters such as plant height, number of tillers and high tillering capacity are deemed indicator of high productivity in arid regions (Sharma & Verma, 1983; Agarwal *et al*., 1999; Mansoor *et al*., 2002) therefore serve as agronomic, as well as morphological descriptors of the prevailing genetic diversity. All accessions were kept under uniform environmental conditions during the experiment; therefore the variation encountered had a genetic basis. However, in spite of all this enormous genetic diversity was observed, which apparently marks the underlying genetic diversity. Similar morphological variations were observed in *L. scindicus* (Yadav & Krishna, 1986; Arshad *et al*., 2009; Nisar *et al*., 2010), *Hedysarum boreale* (Johnson *et al*., 1989), *E. tef* (Zuec) (Tefera *et al*., 1992), *C. jawarancusa* [Jones (Schult)] (Arshad *et al*., 1995), *S. iocladus* (Arshad *et al*., 1999), *Dicanthium annulatum* (Agarwal *et al*., 1999), *C. ciliaris* (Mansoor *et al*., 2002; Arshad *et al*., 2007), *Zizania palustris* var. *palustris* (Lu *et al*., 2005) and *P. antidotale* (Sohail *et al*., 2010).

Patterns of different morpho-types and their adaptations to abiotic stresses, survival issues and grazing pressures on top has pushed these plants to adapt to various associations and therefore acquire active refuge both from severe environmental conditions and grazers. The plants of *P. antidotale* have often been found in associations with

Table IV: Correlation coefficients for different variables recorded

	V1	*V2*	*V3*	*V4*	*V5*	*V6*	*V7*	*V8*	*V9*	*V10*
V2	0.326**									
V3	0.121	0.474**								
V4	0.139	0.112	0.126							
V5	-0.109	-0.114	0.332**	0.308**						
V6	0.198	0.109	0.155	0.558**	0.241					
V7	-0.276*	-0.162	0.264*	0.233	0.146	-0.448**				
V8	-0.191	0.302**	0.084	-0.166	-0.419**	0.141	0.033			
V9	-0.207	-0.015	-0.280*	-0.296*	-0.855**	-0.069	-0.207	0.348**		
V10	0.304**	-0.315	-0.363**	0.162	0.120	-0.142	-0.006	-0.507**	-0.288*	
V11	-0.042	0.016	0.095	-0.108	-0.109	-0.277*	0.192	-0.125	0.076	-0.125

* at 5% and ** at 1% *P* level

V1= Height of the plant; V2= Number of tillers per plant; V3= Number of fertile branches per plant; V4= Number of leaves on main tiller; V5= Length of inflorescence (cm); V6= Number of internodes on main tiller; V7= Flag leaf area (cm^2); V8= 4th node leaf area of main tiller (cm^2); V9= Length of internode covered by leaf sheath at 4th node (cm); V10= Thickness of stem at 4th node of main tiller (mm); V11= Number of spikelets per inflorescence

Table V: Correlation co-efficients between the first three principal components and the morphological characters

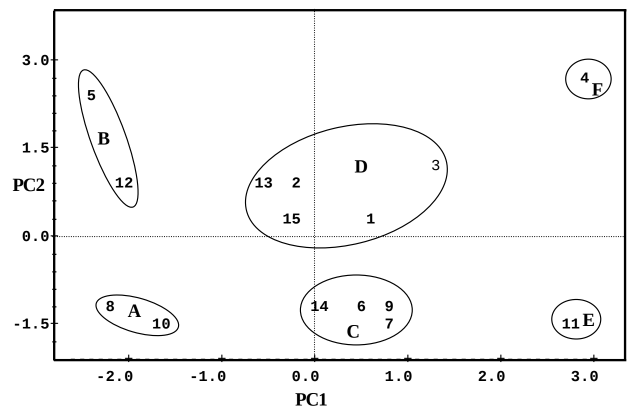
Character	*PC1*	*PC2*	*PC3*
Cumulative Contribution	24.1%	43.1%	59.9%
Height of the plant	-0.167	-0.154	-0.366
Number of tillers per plant	0.036	-0.512	0.027
Number of fertile branches per plant	-0.178	-0.432	0.374
Number of leaves on main tiller	-0.364	-0.193	-0.081
Length of inflorescence (cm)	-0.523	-0.014	0.188
Number of internodes on main tiller	-0.192	-0.409	-0.362
Flag leaf area (cm^2)	-0.098	0.136	0.573
4th node leaf area of main tiller (cm^2)	0.354	-0.354	0.086
Length of internode covered by leaf sheath at 4th node (cm)	0.532	-0.004	-0.148
Thickness of stem at 4th node of main tiller (mm)	-0.264	0.412	-0.296
Number of spikelets per inflorescence	0.092	0.099	0.327

Calligonum polygonoides L., *Capparis decidua* Forssk. (Edgew.) and *Prosopis cineraria* L. (Druce). These associations have become prominent since it helps escape grazing pressures. In addition, the juvenile plants get moisture under the canopy cover.

We utilized similar agro-morphological markers to study the diversity pattern in *P. antidotale* and depicted enormous morphological variation. Characters such as plant height and better tillering capacity are indicators of high productivity in arid regions (Sharma & Verma, 1983; Agarwal *et al*., 1999; Sohail *et al*., 2010). All eleven characters studied, contributed to 1st three principal components, hence informative. Among these ‘number of leaves on main tiller’ (SD = 1.57), ‘tillers per plant’ (SD = 1.49) ‘leaf area of main tiller’ (SD =1.26) etc contributed significantly. However, it remained to be seen as to which other morphological characters would reveal distinct grouping and adaptation in arid environmental conditions.

From the present study, it may be concluded that *P. antidotale* found in Cholistan desert is a relict population holding enough diversity to initiate a conservation project. Our study will further facilitate these efforts to identify accessions to set up a germplasm collection for *P. antidotale*, thus devising an effective conservation strategy.

Fig. 1: Plot of principal component 1 and 2 for different accessions of *P. antidotale* collected from Cholistan desert



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