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Morphological traits characterizing environmental adaptation of some wild plants collected from the Sibi and Quetta Regions of Balochistan

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Abstract

This research explored the Morphological traits of some wild plants of Sibi and Quetta region. The study included three wild plant species, namely Alhagi mourarum Medic., Amaranthus viridis L., and Heliotropium europaeum L. from both sites. Selected study sites were different in their elevations, temperature, rainfall pattern and other abiotic factors. This research therefore, was conducted to understand plant adaption under these varying environmental conditions while perceiving morphological traits of selected wild species in their adapted habitats. Among morphological parameters, Shoot and Root Length, Above-ground (Shoot) Fresh weight, Below-ground (Root) Fresh Weight, Above-ground (Shoot) Dry weight, Below-ground (Root) Dry Weight, Inflorescence length, Spine length, Number of leaves par plant and Leaf Area were evaluated. Results indicated a clear variation in all studies morphological traits between selected plant species of contrasting study sites. Overall finding showed that among morphological traits, leaf area showed a clear and significant difference ((P≤0.05) for all selected plant species while among selected plant species A. mourarum samples collected from both sites viz., Quetta and Sibi showed a significant difference (P≤0.05) in their morphological traits. It was therefore concluded that plants growing under different environmental conditions exhibit changes in their morphological traits to adapt and these findings may serve as a basic information to identify ecophene species in a population within a particular habitat. This data may further be used collect these species viz., Alhagi mourarum, Amaranthus viridis, and Heliotropium europaeum to find underlying physiological and biochemical and even genetic traits aiding these species to adapt in different habitats.

Key Words: Morphological traits, environmental factors, wild plant species, Quetta, Sibi

Introduction

Phenotypic plasticity is one of the major adaptations that allows plants to flourish under different environment, and the adaptive mechanism may be related to the specific environments in which the plants live; that is, different environments may select for plants that have different phenotypic plasticity mechanisms (Bradshaw, 1965; Agrawal, 2001; Rubio De Casas et al., 2007; Engel et al., 2011). It is generally accepted that fluctuating environmental conditions play a key role in the morphological variation in plants (Cordell et al., 1998; Milne et al., 2006). Morphological variation in plants is generally feedback for the changing climatic conditions and reflects the adaptive evolution (Beard, 1973; Aitken et al., 2008; Hoffmann and Sgro, 2011; Alberto et al., 2013; Framks et al., 2014; Merilia and Hendry, 2014). Plants have the ability to alter their morphological traits in response to environmental variations (Sultan, 1995; Robakowski et al., 2003) and adjust the expression of these traits to accommodate their adaptability across multiple environments (McIntyre et al., 2009).

Among different environmental, plant growth and development were influenced by temperature, light and rainfall in several ways (Diaz, 1998; Garnier, 2002). The climatic variability hypothesis suggests that individuals of a species may exhibit larger morphological variation with increasing climatic variability, which could happen in areas of lower precipitation at decreased longitude (Janzen, 1967; Stevens, 1989). The leaf length and width of Pistacia atlantica Desf. subsp. atlantica were found to be significantly related to precipitation, and precipitation is the major factor that determines plant functional traits in Stipa species (El & Benhassaini, 2016; Lü et al., 2016). The interspecific trend previously reported by many scientists between plant traits and climatic factors have found an association between annual mean rainfall, availability of light and leaf shape, leaf area, and leaf size (Wolfe, 1998; Royer, 2008; Jones ,1995; Riaz et al., 2021).

Alongside other environmental variable, altitude was also another factor effecting plant morphological attributes as stunted growth and reduced leaf area was observed in plants growing on high altitude, however, to avoid abiotic stress plants showed an optimum photosynthesis with carbon assimilation (Shi et al., 2006; Oh et al., 2013). Medicinal plants also exhibit morphological adaptations when adopted to habitats with variation in microclimates. Morphological features can be seen in plants when exposed to environmental changes (Sultan 1995; Robakowski et al., 2003; McIntyre 2009).

Such as elevational changes which can impact plant development and structure (Berli et al., 2013; Dogra et al., 2013). As a result, recent plant ecologists considered these plant attributes in different ecological and biological zones to comprehend adaptive traits under certain environmental conditions (Wright et al., 2004; He et al., 2006). The purpose of this study was to explore morphological traits characterizing environmental adaptation of some wild plants collected from two contrasting but natural habitats and to evaluate the relationship between morphological traits and environmental factors.

Study Area

Sibi

The study area Sibi possesses dry climate and varying temperature with different physical attributes. The average mean temperature of Sibi is 96°F in summer and 60°F in winters. The extreme temperature in summer commonly rises to 110° F and less commonly to 120°F. Sibi district is outside of monsoon range, and the rainfall is uneven and less. It varies from lowlands to highlands 4mm to 5mm respectively. Moreover, Sibi lies at elevation of 430 feet high from sea level (Balochistan District Gazetteer Series: Sibi District, 1907).

Quetta

District Quetta contains dry climate. Warm in season of summers and temperate to too cold in winter. Snow may fall in season of January February and December. Quetta lacks sustained and heavy rainfall as it is not in monsoon range. Topographically, District Quetta is hilly and found at elevation of 5510 feet from sea level (District development profile, 2011).

Research Methodology

Field Survey

The present study was conducted in Quetta and Sibi regions of Balochistan. Preliminary data of study sites and test species was obtained after area survey. The survey of study area was done at regular intervals to collect the basic data prior to final research work.

Plant Samples

Plants were selected due to their presence in interested study areas. A total of three plant samples viz., Heliotropium europium L., Alhagi maurorum Medic., Amaranthus viridis L were examined in this study. A. mourarum is a member of family Fabaceae, A. viridis is from Amaranthaceae family, while H. europaeum is from family Boraginaceae. All the selected species were of medicinal value and were being used for different purposes. Plants were carefully studied and then collected from different sites of each study area by random sampling technique.

Morphological parameters

Shoot and Root Length

They were measured with the measuring tape in centimeters (cm)

Above-ground (Shoot) Fresh weight

Above-ground fresh weight was noted immediately after harvesting by an electric weighing balance.

Below-ground (Root) Fresh Weight

Above-ground fresh weight were noted immediately after harvesting by an electric weighing balance.

Above-ground (Shoot) Dry weight

Above-ground (Shoot) dry weight of the samples were noted after oven drying at 65-75^{0}C for 24-48 hours.

Below-ground (Root) Dry Weight

Below-ground (Root) dry weight of the samples were noted after oven drying at 65-75^{0}C for 24-48 hours.

Inflorescence

For each plant sample while during flowering stage Inflorescence was measured in centimeters (cm).

Spine length

The average spine length was calculated for samples with spines.

Number of leaves par plant and Leaf Area

Randomly collected plants were analyzed for leaf numbers and leaf area. Leaf Area was determined by using the method of Cain and Castro (1959), the equation to determine leaf area by 1/4 0.667xLxW, Where L is the length of the leaf, W is the width and 0.667 is the correction factor.

- **Statistical analysis:**

All the results were processed using STATISTI X software to perform analysis of variance (ANOVA) and Least Significance Difference (LSD). A statistically significant difference between samples was true if p-values were found less than 0.05.

Results and discussions:

To evaluate morphological variations among selected plant species viz., A. mourarum, A. viridis, H. europaeum which were collected from study sites of selected study areas viz., Quetta and Sibi. The plants were analyzed for morphological attributes to highlight variations under contrasting environmental factors od study sites. Among morphological parameters, Shoot and Root Length, Above-ground (Shoot) Fresh weight, Below-ground (Root) Fresh Weight, Above-ground (Shoot) Dry weight, Below-ground (Root) Dry Weight, Inflorescence length, Spine length, Number of leaves par plant and Leaf Area were evaluated for each selected plant species and results were compared. Results depicted a decrease in shoot length from low to high altitude (Sibi to Quetta) in case of A. mourarum and H. europaeum except for A. viridis. However, a significant difference ($P \leq 0.05$) was observed in shoot length for A. mourarum samples. The difference in shoot length may be attributed to the differences in soil nutrients (Anderson Ndema, & Edward Missanjo 2015; Hassan et al., 2020; Qi et al., 2020).

Another morphological trait Shoot fresh weight was also measured and an increase was observed in A. viridis and H. europaeum samples collected from Sibi when compared to Quetta samples whereas A. mourarum showed a significant difference ($P \leq 0.05$). Reduction in biomass of plant may be seen at high elevation as an adaptive feature to protect them from destructive effect of strong winds (Körner, 2003). Biomass in various parts of plants is due to the light response. Larger the growth efficiency, i.e., a larger biomass production per unit leaf area with increasing light energy. Total biomass usually decreases with elevation and increases with light (Claveau et al. 2002).

A difference in Shoot dry weight of all selected plant species were observed collected from selected areas. However, H. europaeum samples of Quetta and Sibi showed a significantly different ($P \leq 0.05$) compared to other selected species. Similarly, Root length was also measured in all selected plant species collected from both sites. Results of root length showed a variation between plant samples collected from Sibi when compared to plant samples collected from Quetta. Among selected plant species, root length of A. mourarum samples exhibited a significant difference ($P \leq 0.05$). The results were not in-line with other researchers (Hassan et al., 2020). A decrease in Root fresh weight was observed in all three species collected from Quetta while significant difference ($P \leq 0.05$) was observed for A. mourarum.

Thus, elevation may serve as a factor to induce reduction in root fresh weight. Similarly, a reduction in Root dry weight was observed in A. mourarum and A. viridis on high elevation viz., Quetta compared to Sibi. A. mourarum showed a significant ($P \leq 0.05$) variation in results. Qi et al., 2020 also documented a relation between shoot and length with elevation so it may be considered that in natural habitat alongside other factors elevation also play a key role to influence morphological attributes of wild plant species. Including other morphological factors length of inflorescence and spines if present was also measured in plant samples collected from both selected sites. Results showed that inflorescence length was relatively high in plant samples collected from Quetta region. Spines were present in A. mourarum collected from both sites and showed a significant difference ($P \leq 0.05$) between samples of selected areas. Leaf area in a wild plant species may be influence by variety of factors.

According to Körner, 2003, the decline of plant biomass due to elevation may also influence leaf areas along the altitude gradient. However, leaf area may also be influenced by limited water supply (Riaz et al., 2021). Present study also documented a variation in leaf area of all selected plant species. There was a significant difference($P \leq 0.05$) between leaf areas of all selected plants collected from Quetta and Sibi region. This variation in leaf area may help plant to adapt in different habitats. It is also suggested that plant leaves on low elevation adapted to low intensity of light by producing larger leaves. Furthermore, potential adaptation demands leaf plasticity for specific light conditions (Guidi and Calatayud, 2014). It was further evaluated that plants are well adapted to dry environments by improving leaf vein density and reducing leaf area (Nardini et al., 2010; Sack & Scoffoni, 2013). Apart from leaf area, number of leaves per plant was also calculated and results again showed a variation indicating plant adaptation pattern to respect to environmental factors. However, a significant difference was observed in H. europaeum samples collected from both sites.

Table 2: Morphological attributes of selected wild plants collected from Sibi and Quetta region

Parameters	***A.* mourarum**		**A. viridis**		**H. europaeum**	
	S	Q	S	Q	S	Q
Shoot length(cm)	62.64± 5.94[a]	42.33± 8.02[b]	43.56± 12.65[a]	57.66± 27.06[a]	59.5± 12.55[a]	57.59± 10.13[a]
Shoot fresh weight(g)	109.33± 27.59[a]	59.66± 5.50[b]	18± 2.64[a]	36± 22.33[a]	122± 74.47[a]	164.66± 33.50[a]
Shoot dry weight(g)	47± 9.84[a]	31.69± 12.45[a]	3.97± 1.23[a]	9.16± 6.55[a]	18.79± 13.33[b]	55.83± 16.84[a]

Root length(g)	271.27± 10.98[a]	163.83± 23.69[b]	13.76± 1.62[a]	16.66± 8.14[a]	25.33± 1.52[a]	26.66± 9.81[a]
Root fresh weight(g)	276± 92.77[a]	54.86± 14.84[b]	2.30± 2.39[a]	1.96± 0.05[a]	8.63± 4.31[a]	7.5± 4.09[a]
Root dry weight(g)	121± 32.41[a]	24.67± 6.78[b]	1.87± 1.89[a]	0.69± 0.36[a]	1.69± 0.96[a]	3.01± 0.97[a]
Inflorescence length(cm)	--	--	7.53± 2.62[a]	11.66± 6.63[a]	3.3± 0.26[b]	5.43± 0.51[a]
Spine length	5± 0.5[a]	3.03± 0.46[b]	--	--	--	--
Leaf area (cm^2)	1.35± 0.13[a]	0.23± 0.06[b]	9.76± 2.58[b]	33.57± 13.92[a]	15.45± 1.75[a]	3.82± 1.40[b]
Number of leaves	1704.67± 192.36[a]	1786± 199.02[a]	188± 29.81[a]	138.33± 64.63[a]	290± 137.27[b]	782± 140.81[a]

(S) Sibi (Q) Quetta, Mean±Standard Deviation, N = 3. Different alphabets/letters on data represent statistically significant interaction ($p < 0.05$) according to LSD (least significant difference) test.

Conclusion

Plant growing under different environmental conditions always adapt to thrive. Morphological variation can evolve in response to such environmental variability may serve as a basic information to identify ecophene species in a population within a particular habitat. These morphological adations may be used as basic criterion to select plant species that will display high fitness in new environments and thus, may help to ensure in situ conservation of some important wild flora. It is therefore concluded that the results provided in present study may be used as a base-line data to explore potential of wild flora under contrasting environmental factors while highlighting plant ability to adapt. However further research work is recommended to evaluate underlying physiological, biochemical and even genetic traits aiding plants under different habitats.

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