World Journal of Environmental Biosciences

Available Online at: **www.environmentaljournals.org**

Volume 8, Issue 3: 46-55

ISSN 2277- 8047

Environmental and Genetic Diversity of Rangeland Plant Species in Saudi Arabia (Review Article)

Haifa Abdulaziz S Alhaithloul

Biology Department, College of Science, Jouf University, Sakaka, Kingdom of Saudi Arabia.

ABSTRACT

Rangelands in Saudi Arabia comprise about 75% of the country's total area of more than 175 Million Hectares; however, woodland forests occupy only 2.7 Million Hectares. The variability in the landscape has been reflected in variations in terrestrial plant species. Range vegetation and forest understory vegetation have a long history of grazing by livestock and wildlife herbivores. Many of the Rangeland plants in K.S.A. are a menace because of poor regeneration under multiple environmental stresses such as salinity and drought, and as a result of dense overuse, grazing and other human activities. According to these reasons, their preservation and improvement through molecular and biotechnology methods are unavoidable. In addition, investigations on the genetic and environmental variability among species and genera in the vegetation of K.S.A. are little. Therefore, the quantification of environmental and genetic variability is the primary goal in conservation efforts. This review will look over the studies that have investigated vegetation diversity and will discuss the current practices in Saudi Arabia to conserve rangeland variance as an important solution for grazing.

Keywords: *Saudi Arabia, Rangeland, grazing, genetic diversity, Molecular marker*

Corresponding author: Haifa Abdulaziz S Alhaithloul
e-mail ✉ haifasakit @ ju.edu.sa
Received: 11 February 2019
Accepted: 15 August 2019

1. INTRODUCTION

Saudi Arabia is distinguished by its various ecosystems and plant species variation (Abdel Khalik et al., 2013). Various habitats in K.S.A include mountains, meadows, valleys, rocky and sandy deserts, and saltpans (Al-Nafie, 2008). Water extracted from aquifers is the major factor in any agriculture system. Alfalfa [*Medicago sativa*] is the main fodder crop represent %56 of the total forage area in K.S.A. whereas Rhodes [*Chloris gayana*] and blue banic [*Panicum antidotale*] represent most of the residual areas. It produces a high production of the total dry matter yield among forage species. Al-Doss, (1997) stated that Alfalfa does not grow naturally and is not adapted to the common severe conditions of temperature, drought, and salinity. It needs a large amount of water often coming from nonrenewable groundwater sources. In K.S.A., there are various livestock [camel, sheep, goats, and cattle] that exceed 3.5 million heads (Bakhashwain, 2010). It is desirable to introduce alternative species that are high in total DMY and forage nutritive value, and low in water consumption (Al-Soqeer, 2016). The importance of conservation is genetic exchange through recombination and random mating, acclimation of helpful transfer and mutation among the populations, and competition among populations (Vijayan et al., 2011). This review article will discuss the factors that affect the variability in rangeland plant species in two levels. The first level is environment diversity that includes different factors including topography, climate, and habitats. The second level is genetic diversity that includes morphological, biochemical, and DNA based markers.

1.1 The Situation of Rangelands in Saudi Arabia

Worldwide, natural grasslands and rangelands have been severely degraded in recent decades (Conant et al., 2017). Rangeland ecosystems have different benefits as eco-tourism (Seddon, 2000) and watershed management. The flora of K.S.A. is rich in variability with many endangered plant species (Al-Rowaily, 1999). The complexity of the vegetation makes the major rangelands' resources for livestock. Al-Rowaily (1999 and 2003) stated that livestock grazing is the predominant form of land use. More than two-thirds of the rangelands of the K.S.A. have been destroyed by overgrazing (Kingery, 1972). Al-Rowaily (2003) found that quick economic and social variations during the past few decades, lead to heavy and prolonged pressure on rangeland ecosystems. Fuelwood cutting, overgrazing and cultivation pressure cause strong environmental retrogression to most of rangelands in K.S.A. Many human activities increase erosion, vegetation retrogression, and deterioration (Kingery, 1972). In addition, Overgrazing and the growth of the human population have been reported as the main factors causing the loss of biological diversity of natural grasslands (Aukema et al., 2017). It is now well documented that invasive alien species are the second major threat to biodiversity after habitat loss (Thapa & Maharajan, 2014). Meanwhile, as reported by Dogra et al. (2010), the invasion by exotic species was considered to be the main disturbing factor of wild ecosystems. Alghamdi et al. (2018) confirmed the presence of some noxious and invasive weeds and this should raise the alarm to the local authority to take rapid actions in order to prevent destructing the natural vegetation of Jabal Salma by these noxious species. In addition, Mseddi et al. (2017) stated that various invasive plant species have been introduced to natural landscapes of Hail from neighboring alfalfa and wheat fields of the surrounding areas.

Rangelands of Saudi Arabia strongly suffer from harsh climates where high temperature and prolonged droughts occur alongside intensive grazing (Baig et al., 2017). Because of these conditions, there was reduction in the structure of species and variability (Al-Rowaily, 1999; Barth, 1999). Many investigations explained the natural flora of K.S.A. (El-Ghanim et al., 2010; Watts & Al-Nafie, 2013).

Recently, Alghamdi et al., (2018) reported that the Saudi ministry of environment and water and agriculture has set new ambitious plans to combat desertification and save the country's natural landscapes including rangelands, grasslands, forests, and wild areas. This ministry has launched a restoration program for natural landscapes by planting four million trees by the end of 2020. This program is designed to revive the Saudi flora by replanting native species such as shrubs and trees (Heneidy et al., 2017). Thus, the K.S.A government should carefully look for the original resources of local seed varieties that by 2020 can be planted in millions. Such native seed species can be collected from natural enclosure habitats, which are difficult to grazing animals and humans to access. According to Mseddi et al., (2016), enclosure rangelands for 15 years can restore a large proportion of local seed species. We argued that native seed species can be used in the programs of restoration and exploitation of economically valuable species [including medicinal, forage, and ornamental species], which currently are completely disappeared in the natural regions.

Alghamdi (2017) proved the collection of native seed species in the K.S.A especially in the Hail region who successfully collected 40 species from the protected rangeland zone compared to the neighboring open area of which only 15 species were collected.

2. FLORA IN SAUDI ARABIA

The flora of K.S.A. belongs to the Arabian sub-zone (Al-Nafie, 2008). The most comprehensive studies of floras have been reported in 1974 and 1996 (Mighaid, 1996; Chaudhary 1999, 2000, & 2001). Another article explained the flowers of K.S.A. (Collenette, 1999).

The flora of K.S.A. includes different genetic resources of vegetation, which makes the features of life in K.S.A. plants (Mossa et al., 1987; Khan et al., 2012). Collenette (1998) recorded 2250 species, 142 families, and 835 genera in Saudi Arabia. Al-Nafie (2008) stated that the Compositae considered being the largest family in Saudi Arabia. Moreover, Al-Turki (2002) reported a whole picture of the flora of the K.S.A, which is not completed.

The floristic investigations help us to assess the plant wealth and its potentiality in any particular area and comprehension of the basic aspects of biology as segregation, speciation, development, and endemism. The variability of local flora has a basic role in conserving environmental constancy (Cunningham et al., 2015). There is a constant threat because of the environmental conditions like changeful weather, modified soil pH and composition, salinity, drought, high temperatures, heavy metals stress, altitudes, and habitat fragmentation. Thus, the number of threatened plants is increasing annually due to severe conditions (Khan et al., 2012).

3. ENVIRONMENTAL VARIABILITY

The vegetation depends on the integration of climate conditions, plant habit, dominant species, and phenology (El-Demerdash et al., 1995). ''The dominant" type, i.e. the most abundant species in each community and its floristic composition include a number of associates. Al-yemen & Zayed (1999) found that environmental stress remarkably affects the composition and structure of *perennial herbaceous* species. New traits help species adapt to new condition. (Mazer & Wolfe 1992) stated that water and temperature, affect the phenotypic traits of *M. keisak*, particularly the plant length and biomass.

The climate and topography of the area are the most important factors that affect the degree of speciation (Shaltout & Mady, 1996; Al-Shammari & Sharawy, 2010). Taia and El-Olyan (2005) showed that water availability is an important factor affecting the plant. However, the observed variation in vegetative traits in the species was not significant [status of the plant, its color, fruiting stage, and degree of branching]. Mahmoud & El-Tom (1985) ignored the effects of environmental changes on morphology and studied the effect of salinity on the flora and level of speciation.

3.1. Climate

K.S.A. climate varies between the interior and the coast (Country Profile: Saudi Arabia, 2006). Generally, most regions of K.S.A. are characterized by unexpected and low-erratic rainfall and high temperature (Shmida, 1985). Climatic conditions are harsh that lead to reduced plant population, fragmented habitats, low genetic variation, poor restoration, and rarity in K.S.A (Al-Farhan et al., 2005). Al-Soqeer et al. (2016) studied the variability between grass species under the central region of Saudi Arabia, which has a dry climate. The results showed that there is variability between grass species in their adaption under high summer and low winter temperatures (Al-Ghumaiz & Motawei, 2011). Some places such as Hijaz, Asir area have more variability because of greater rainfall and height (Collenette, 1998).

3.2 Habitats

Many studies have investigated the floristic survey in the middle part of K.S.A. Al-Turki, (1997) studied Al-Qassim flora and found a total of 450 species. On the other hand, Al-Turki & Al-Olayan (2003) analyzed the flora of Hail and detected 338 wild plants. Several other investigations studied Asir and El-Hijaz regions. Batanouny & Baeshain (1983) and Fayed & Zayed (1999) studied the flora types in Al-Madinah-Badr road in the Hijaz Mountains and along Makkah-Taif road, respectively. In the Middle part of K.S.A., the Raudhas vegetation was recorded by Shaltout & Madi (1996). Moreover, Al-Farhan (2001) studied the flora of *Raudhat Khuraim* and comparative studies were carried out by Al-Ghanim, (2002) in the Riyadh region. Sharawy & Al-Shammari (2009) showed the contribution of toxic plants in the Aja Mountains in Hail. In addition, Al-yemen & Zayed (1999) found that the vegetation along Riyadh Al-Thumamah is characterized by nine distinct community types. Historically, the Hail region was considered an excellent area for forage and pasture throughout the year (Al-Rowaily et al., 2016). The largest family of angiosperms in Hail is *Asteraceae* (El-Ghanim et al., 2010). Another large family is Poaceae. These findings matched with the results of the study conducted by Al-Turki & Al-Olayan (2003). The flora of northern areas, particularly in Al Jouf region predominates by annual species. Salsoleae is distributed over arid and semiarid regions. These environments serve adequate habitats for it according to the physiological, anatomical, and morphological traits (Kadereit et al., 2003). Al-Khulaidi (2013) stated that the flora of the Al-Baha region is a mix of tropical African, Sudanian plant geographical. Little research has been done on the vegetation of Al-Baha and focused on the recording of few or individual plant species and vegetation (Collenette, 1985; Al-Aklabi et al., 2014). The mountains of Al Baha are considered as one of most significant plant diversity areas in K.S.A. Although, Al-Baha is a small region in K.S.A., new investigations have recorded about 230 plant species (Al-Aklabi et al., 2016). In addition, in the Alaqan region, 102 plant species have been recorded from 75 genera and 34 families [North Tabuk city], suggesting the low plant flora in this region (Moawed, 2016).

3.3 Topography

Several studies stated the relationship between the height in the Asir mountains and vegetation change and between the vegetation analysis and species variability in Wadi El-Ghayl in Asir mountains (Fahmy & Hassan, 2005) and El-Hijaz mountains (Abulfatih, 1992). Alsherif et al., (2016) studied the plant species in Al-Shafa. This part is important because the elevation range extends to 2.300 m above sea level. Alghamdi et al., (2018) analyzed the floristic composition in Jabal Salma in the east of the Hail region. They showed that the family Asteraceae followed by Brassicaceae, Fabaceae, Boraginaceae, Caryophyllaceae, and Poaceae were the most dominant families. El-Ghanim et al., 2010 studied the dominance of Asteraceae, Brassicaceae, and Poaceae families, which was also stated by Al-Turki & Al-Olayan (2003). They found that the most widespread genus was Astragalus [Asteraceae], which was represented by 8 species followed by Arnebia [Boraginaceae] and Fagonia [Zygophyllaceae] with three species for each family. El-Ghanim et al., (2010) revealed that Euphorbia, Heliotropium, and Plantago were the most widespread genera. Each of these genera was represented by 3 species. Moreover, the most common genera in Hail were *Plantago* and *Astragalus* (Al-Turki & Al-Olayan, 2003). In addition, Alghamdi et al. (2018) showed a very high plant diversity with the richness index of 150 species belonging to 39 families that represented 6.9% of the total plant species scored in Saudi Arabia. In general, the low biodiversity percentage of Jabal Salma may be due to the harsh environmental conditions, particularly low rainfall and high temperature that resemble the Sahara climate that covers most of the country (El-Ghanim et al., 2010). According to these findings, Jabal Salma holds many species of economic values. These results would confirm the biological diversity of mountains as a special habitat in Saudi Arabia. In accordance with these results, a recent similar study was carried out by Al-Zubaide et al. (2017) to assess the floristic composition of Shada Mountain in the south of Saudi Arabia and found many species of economic value including medicinal, grazing, fuel, and edible plants. Alsherif et al., (2016) found a high number of taxa in Al-Shafa Highlands in Taif due to a higher variability compared to other regions in K.S.A. such as Bisha and Aseer regions [145 spp.; (Heneidy et al., 2017)], and Aseer Mountains [189 spp.; (Al-Yemeni & Sher, 2010)]. Wild plants in Najd regions are linked with aridity and drought. (Collenette, 1999, 2000, & 2001). According to an investigation, the most frequent species in Central K.S.A. was *Haloxylon salicornicum*, which was found in a large area (Al-Rowaily., et al., 2018).

The term ‘‘Wadi’’ indicates a non-permanent river. Kassas & Girgis (1964) stated that Wadis represent physiographic abnormality that leads to differences in the distribution of plant species. In addition, Wadi ecosystems are very important for socio-economic development due to their physiographic variation and ecological significance. Generally, the vegetation of wadis varies every year depending on various factors including moisture levels (Siddiqui and Al-Harbi, 1995), regeneration, growth control, the establishment in Wadis like geographical location, physiographic characterizes, and human impact (Korkmaz & Ozcelik, 2013).

Biological research has been considerable in the wadi ecosystems in Najd Region and are among the main plant diversity centers of central K.S.A. But analysis on its floristic components are insubstantial (Chaudhary & Al-Jowaid 1999). In Wadi Al-Jufair, there are 157 species that belong to 133 genera. Asteraceae and Poaceae considered being the most prevalent families. Therophytes constituted 81 species Al-Atar et al., (2012).

In Wadi ‘‘Arar’’ on the Northern region of K.S.A. Osman et al., (2014) and Osman & Abdein (2019b) found 196 species belonging to 31 families of phanerogams these studeis agrees with (Quezel, 1978). Al-Hassan (2006) showed that about 456 species in the northern part of the K.S.A. 265 species belong to 200 genera in 70 families were found in Wadi Turbah Zahran. The highly represented families were Asteraceae, Poaceae, Brassicaceae, Lamiaceae, Amaranthaceae, Solanaceae and Apocynacaeae Al-Robai, et al., (2017). In addition, Osman et al. (2014), revealed that northern and southwestern Saudi Arabia contain the highest number of species. Moreover, in the western mountainous of Saudi Arabia there is the greatest diversity of species (Collenette, 1998).

Korner (2000) found that mountains greatly affect the types of global species richness. Mountains support various endemic species and shelter specialized plant communities (Collenette, 1998 and Korner, 2000). In the same context, plants growing at high mountains were different from plants growing at a lower height (Badr et al., 2012).

4. GENETIC VARIABILITY

Genetic variability refers to the genetic makeup of a species (Given, 1994). Abdel-Mawgood, (2005) stated that the genetic variations within the population have major importance for adaptation to environmental changes and longtime survival of a species. The lack of genetic diversity in a population leads to an increasing number of homozygous individuals within a population, which is related to the lack of individual efficiency. Gaafar et al., (2014) investigated the genetic variability within and between the population of endangered and rare plants to improve our comprehension of acclimation and for the development of conservation plans. This estimation is important because the evolution relies on keeping enough genetic variability within and among the plant populations to accommodate new selection pressures caused by environmental change (Lande, 1988).

Genetic diversity studies are very important for endangered and rare plant species from their natural habitat. It will be useful in making plans for management for preserving their genetic diversity and assuring their long-range existence. In addition, to measure whether a rare species indeed exhibits low genetic diversity, it is important to comparing genetic variability in the rare species with those of a more widespread was done by (Gitzendanner & Soltis, 2000). Therefore, it is necessary to establish genetic fidelity and estimate the genetic consistency of wild plants by utilizing different techniques such as cytological, isozymes, and molecular markers (Mallón et al., 2010). Geographic distribution range, demographic history, reproductive systems, seed and pollen spread are factors that affect the genetic variability (Hamrick & Godt, 1990; Nybom, 2004). Genetic variability is affected by many geographical factors leading to the formation of subspecies and ecotypes in nature (Sreekumar & Renuka, 2006). Moreover, it is influenced by the population size of a plant species and the number of individuals. Therefore, reducing genetic variability and inbreeding risk result from decreasing the population size (Reed & Frankham, 2003). To evaluate the genetic variability, a single marker is not enough and other markers should be used.

4.1 Morphological traits

Morphological variation in response to environmental troubles is recognized as phenotypic flexibility, while inner variation is considered acclimation. Badr et al. (2012) showed that morphological criteria reflect the variations between three Artemisia populations. Meanwhile, they stated no direct relationship between geographic distance, genetic distance, and morphological traits. In the same trend, Barney & DiTommaso (2003) studied a broad morphological variability among *A. vulgaris* populations and found plants differ in leaf length and morphology. Molecular, morphological, and variability were addressed in 3 species *A. vulgaris* L., *A. roxburghiana* Wall. ex Besser, and *A. absinthium* L by Nazar & Mahmoud, (2011). The results showed that geographic conditions affect the active constituents of the medicinal plants. In a similar way, Hasan et al., (2009a and b) observed the genetic differences of *A. capillaris* in various parts of Malaysia. Abdel-Hamid (2016) found differences in the morphological traits between four salsola species all of which were perennial and small shrubs.

4.2 DNA based markers

DNA markers are more reproducible than the morphological, Karyological, and protein markers as they have been long practiced for the identification of variations in genetic diversity studies. Osman & Abdein (2019a) studied cytological and molecular variations between 6 species of *Plantago* in the Northern region at K.S.A. In addition, these markers are highly detectible, reliable, (Henry, 2001) stated that molecular markers provide useful proof for evaluating genetic variability and described methods used for plant genotyping. With the advance of molecular techniques, many types of molecular techniques including RFLP, RAPD, SSRs, AFLP, and ISSR have been used to characterize species.

4.2.1 ISSR

Al-Qurainy et al., (2018) used 15 primers of ISSR molecular markers to study genetic diversity. All studied primers generated monomorphic bands as the result of two primers. These results were matched with many investigations as they did not find any genetic variability on tissue culture plantlets in Banana *cv* Robusta (Goyal et al., 2015), *Tylophora indica* (Sharma et al., 2014) studied ISSR markers have been utilized for the estimating of genetic fidelity in the tissue culture plantlets including *Bambusa balcoa* (Negi & Saxena, 2010). One of the most endangered plants of southwestern K.S.A. is *Breonadia Ridsdale* [Rubiaceae] (Al-Turki, 2002). Gaafar et al., (2014) used ISSR to study genetic variability within and among *B. salicina* in K.S.A. The 14 primers produced 211 DNA bands. These levels of genetic variability are lower than other investigations based on the ISSR markers of endangered plants (Uysal et al., 2012). Moreover, ISSR primers created 51 polymorphic bands from the Yemeni population. The type of breeding system within and among populations is the most important factor that affects genetic diversity (Hamrick & Godt, 1990; He & Liu, 2003). The genetic variability in *B. salicina* at the population levels is lower than the average means of both outcrossing plants (Nybom, 2004).

4.2.2 AFLP

Abdel-Hamid (2016) found that there are wider variations between *Salsola schweinfurthii* growing in Nayal valley compared to *Salsola cyclophylla* growing in the Hammad area by using the combination of 3 AFLP primers. The analysis produced 181 fragments of which 133 were polymorphic. These indicated that the molecular genetic variations may be due to the local, ecological, and geographical conditions, which were consistent with the study by Badr et al. (2012).

4.2.3 RAPD

Capparis deciduas is a rangeland plant species growing in the K.S.A. Abdel-Mawgood (2005) studied the genetic diversity within a population of *Capparis deciduas* using 12 RAPD primers. The amplification of 14 individuals produced 85 scorable bands. Several molecular markers were used in different studies related to *Lamiaceae taxa*: RAPD (Shinwari et al., 2011), ESTs (Karaca et al., 2013). SSR ESTs (Karaca et al., 2013). Various polymorphism levels has been reported with DNA markers in different *Lamiaceae taxa* and their population including *Teucrium polium* (Boulila et al., 2010), *Rosmarinus officinalis* (Zaouali et al., 2012), *Mentha cervine* (Rodrigues et al., 2013), *Salvia officinalis*, *Micromeria* (Puppo et al., 2016) through using various molecular techniques. In this context, Ahmed & Alamer (2018) studied four species; *L. dentata, L. pubescens, M. longifolia* and *M. viridis* belong to family *Lamiaceae* using 1 RAPD primer, 3 coding DNA genomic regions, and 3 pairs of microsatellite SSR primer [*matK*-KIM, *matK*-pK and NY] for the plastid gene Maturase K. The 7 primers generated 16 bands of which 14 were polymorphic indicating a high level of polymorphism. These results were similar to those of (Al-Rawashdeh, 2011) who reported a unique DNA sequence for *Mentha spicata* and *Ziziphora tenuior* using RAPD markers and differed from those scored by (Jabeen et al., 2012) who showed high similarity coefficient between *M. spicata* and *M. longifolia* using three chloroplast genes [*rbs*]. On the other hand, Hammad et al. (2010) used 19 primers RAPD markers to study the genetic diversity in 12 samples of 3 species of *Zygophyllum* in Egypt and K.S.A. Just 5 primers showed reproducible results. Similar results were obtained by (Li et al., 2008). Moreover, other researchers worked with the same genus but with other species (Hepsibha et al., 2010). Species of this genus have drought resistant and/or salt tolerant, living under hard, dry climatic conditions; moreover, it is estimated by many authors (Batanouny & Ezzat, 1971) as one of the important components of the desert vegetation. Many investigations studied the molecular analysis of Artemisia carried out by (Al-Rawashdeh, 2011; and Badr et al., 2012;). Motawei et al., (2012) studied genetic diversity between six grass genotypes using 15 ISSR.

4.3 Isozymes

Limited work has been conducted on the discrimination and characterization of *Lamiaceae* species in the KSA by using allozyme and other molecular markers. Allozyme electrophoresis used to estimate the genetic variability and the population structure in *Thymus* (Lopez-Pujol et al., 2004), *Rosmarinus officinalis* (Zaouali et al., 2012), *Lavandula multifida* (Chograni et al., 2012) and *Ocimum* (Mustafa et al., 2006). Ahmed & Alamer (2018) showed a total of 26 alleles scored among the 19 loci from 5 isozymes investigated. Obviously, the observed heterozygosities were higher than expected in 6 species. Similar results were obtained in *Lavandula multifida* and *Thymus loscosii* populations (Chograni et al., 2008 and Lopez-Pujol et al., 2004). Values in all species were lower than zero except *L. dentata*. The negative values of the inbreeding coefficient [*F*] referred to excess in heterozygosity. The increased heterozygosity was also reported in *Lavandula multifidi*, *Lavandula stoechas,* and *Rosmarinus officinalis* (Chograni et al., 2008, 2012). The decline in genetic diversity may be due to the self-compatibility of *Lamiaceae* species and the low number of individuals in each species. This result was in accordance with those of (Hamrick & Godt 1990; Leimu et al., 2006) concluding that in self-compatible species, the genetic variation largely stayed among populations not within them. Recently, Abdein (2018) studied two isozymes (POD) and (PPO) to differentiate the 16 accessions of the 2 studied taxa in pumpkin in Northern Border Region in Saudi Arabia; each of them had 6 polymorphic bands.

4.4 Gene Expression Studies

Seeds of *Atriplex halimus* L. are able to produce big biomass (Glenn et al., 1999). Moreover, it has been used as livestock fodder. Dehydrins [DHNs] gene has essential roles in plant response to different abiotic stresses (Hanin et al., 2011). Sadder et al. (2014) used *Atriplex* spp. to clone and study the expression of the *AhDHN* gene under salinity stress. The expression was equally expressed under control conditions. On the other hand, under the salinity stress, the transcription level jumped 7-times in root tissue comparing to the control. In the same context, in the *spinach Spinacia oleracea* DHN gene reveal a role in tolerance to osmotic stress (Chen et al., 2012). Moreover, DHNs are effective in salinity tolerance in *Suaeda asparagoides*.

4.5 Sequence Analysis

DNA sequences are very useful in the development of single markers, which could be used as a DNA barcode for the species. Hebert et al. (2003) were the first researchers who used the term DNA barcode that acquired worldwide attention in the scientific society (Chen et al., 2010). Sequence alignment between AhDHN and its homolog AcDHN detected large variations. Actually, major genetic variations were detected between a group of *A. halimus* cultivars and *A. canescens* as revealed by ISSR DNA markers. These variations were also assured by the phylogenetic tree, highlighting the novelty of the AhDHN gene. Sequencing- and non-sequencing-based markers have been utilized in plant species to detect adulterants in the local herbal markets (Al-Qurainy et al., 2011a; Khan et al., 2011) Presently, inner transcribed spacer sequences of nrDNA and chloroplast DNA markers are used for the precise of plant species (Chen et al., 2010; Al-Qurainy et al., 2011b).

5. FUTURE VIEW

The outcome of such a review is to outline the current research on the environmental and genetic changes on rangeland plant species in Saudi Arabia. To expand the genetic base of the endangered plant species, suitable management and conservation strategies require implementation. The population size is a factor for restoration species (Allendorf, 1986). For this reason, it will be very important to establish a protected area for endangered plants to decrease the effect of human activities. Moreover, to improve the level of genetic diversity over time, the opportunity of gene exchange and recombination, it will be useful to introduce plants from other populations and cross different populations. In addition, it will be very helpful, to gather all the germplasm in gene banks. This will give significant value for the preservation of genetic variability. Importantly, integrate the local people in the implementation of any strategy.

6. CONCLUSION

This review showed that there is a real need for a quantitative evaluation of the status of Saudi Arabia's rangeland. The trend of the government in Saudi Arabia of reducing the cultivation of forage crops makes improving the rangelands in Saudi Arabia very vital. The K.S.A. rangeland ecosystems have strong retrogression for the last few years. Many challenges will face rangeland including the identification of the reasons for overexploitation, loss of habitat, depletion of natural resources, over-grazing, and rapid urbanization. The efficient measures must be executed to restoring disturbed rangeland in K.S.A rangeland. Each wild species had various environment, topography, and vegetation structure. Many factors such as fogs, aspect, height, slope, moisture, soil, habitats, and topography were strongly correlated with species composition. In addition, most of the endemic plants of K.S.A have little research articles on their molecular characterization. Diverse markers are needful for its precise identification and further use for characterization and distinguishing between different species of wild endemic species and giving a clear view about the genetic relationships between them. Moreover, research purposes either in the pharmaceutical industry or in genetic engineering. Finally, the environmental and genetically variability within and between endangered species is necessary for the future of humanity.

REFERENCES

1. Abdein, M. A. E. H. (2018). Genetic Diversity between Pumpkin Accessions Growing in the Northern Border Region in Saudi Arabia Based on Biochemical and Molecular Parameters. *Egyptian Journal of Botany*, *58*(3), 463-476.
2. Abdel-Hamid, A. M. (2016). Characterization of four salsola species and their genetic relationship by aflp. *Pak. J. Bot*, *48*(3), 1183-1187.
3. Abdel-Mawgood, A. L., Assaeed, A., & Al-Abdallatif, T. (2005, March). Genetic diversity in an isolated population of Capparis decidua. In *Proceeding of the workshop The role of biotechnology for the characterization and conservation of crop, forestry, animal and fishery genetic resources* (pp. 187-188).
4. Abulfatih, H. A. (1992). Vegetation zonation along an altitudinal gradient between sea level and 3000 meters in southwestern Saudi Arabia. *J. KING SAUD UNIV., SCI.*, *4*(1), 57-97.
5. Ahmed, S. M., & Alamer, K. H. (2018). Discriminating Lamiaceae Species from Saudi Arabia Using Allozyme and Specific Dna Markers. *Pakistan Journal of Botany*, *50*(3), 969-975.
6. Al Zubaide, M. A., Al Zahrani, H. S., & Al Toukhy, A. A. (2017). Floristic Composition and Life Forms for Wild Plants of Shada Highest Mountain and Wadi Sagamah at Al Baha Area, Saudi Arabia. *Middle-East Journal of Scientific Research*, *25*(6), 1342-1348.
7. Al-Aklabi, A., Al-Khulaidi, A. W., Hussain, A., & Al-Sagheer, N. (2016). Main vegetation types and plant species diversity along an altitudinal gradient of Al Baha region, Saudi Arabia. *Saudi journal of biological sciences*, *23*(6), 687-697.
8. Alaklabi, A., Arif, I. A., Bafeel, S. O., Alfarhan, A. H., Ahamed, A., Thomas, J., & Bakir, M. A. (2014). Nucleotide based validation of the endangered plant'Diospyros mespiliformis'(Ebenaceae) by evaluating short sequence region of plastid rbcL gene. *Plant Omics*, *7*(2), 102.
9. Alatar, A., El-Sheikh, M. A., & Thomas, J. (2012). RETRACTED: Vegetation analysis of Wadi Al-Jufair, a hyper-arid region in Najd, Saudi Arabia.
10. Al-Doss A. A., Ghandorah M. O., and Moustafa K. A. (1997). Effect of planting date and cutting treatment on forage and grain production of barley. pp. 71-82. Proceedings of the 1st Saudin Symposium on Agric. Sci. Vol. 2, King Saud Univ., Riyadh. pp. 71-82.
11. Alfarhan, A. H. (2001). A floristic account on Raudhat Khuraim Central Province Saudi Arabia. *Saudi Journal of Biological Sciences*, *8*(1), 80-103.
12. Al-Farhan, A., Al-Turki, T. A., & Basahy, R. A. (2005). Flora of Jizan Region, Final Report of project AR-17-7. *King Abdulaziz City for Science and Technology (KACST), KSA*, *1*, 1-545.
13. Alghamdi, A. A. (2017). Quantifying the level of degradation in two adjacent rangeland areas in Ha'il district. *IJAR*, *3*(3), 107-110.
14. Alghamdi, A., Mseddi, K., Abdelgadir, M., & Sharawy, S. (2018). Inaccessible Zones Of Jabal Salma, Ha'il Region In Saudi Arabia: A Reservoir For Native Seed Species. *Journal of Experimental Biology and Agricultural Sciences, ; 6* (3) 572 – 581.
15. Al-Ghanim, W. M. (2002). *Comparative Ecological Studies on the Natural Vegetation of Three Different Transects Within El-Riyadh Region* (Doctoral dissertation, PhD Thesis, Girls College of Education, Ministry of Higher Education, Riyadh Saudi Arabia).
16. Al-Ghumaiz, N. S., & Motawei, M. I. (2011). Productivity, forage quality and presence of dehydrin genes in some introduced pasture grass cultivars growing under heat stress in central region of Saudi Arabia. *Australian Journal of Crop Science*, *5*(8), 1001.
17. Al-Hassan, H. O. (2006). *Wild plants of the northern region of the Kingdom of Saudi Arabia:(field guide with photographs)*. Kingdom of Saudi Arabia, Ministry of Agriculture.
18. Al-Khulaidi, A. A. (2013). Flora of Yemen (Checklist of Flora). *The Sustainable Natural Resource Management Project II, Funded by EPA and UNDP: Republic of Yemen*, 156.
19. Allendorf, F. W. (1986). Genetic drift and the loss of alleles versus heterozygosity. *Zoo biology*, *5*(2), 181-190.
20. AlNafie, A. H. (2008). Phytogeography of Saudi Arabia. *Saudi Journal of Biological Sciences*, *15*(1), 159-176.
21. Al-Qurainy, F., Khan, S., Al-Hemaid, F. M., Ali, M. A., Tarroum, M., & Ashraf, M. (2011a). Assessing molecular signature for some potential date (Phoenix dactylifera L.) cultivars from Saudi Arabia, based on chloroplast DNA sequences rpoB and psbA-trnH. *International journal of molecular sciences*, *12*(10), 6871-6880.
22. Al-Qurainy, F., Khan, S., Tarroum, M., Al-Hemaid, F. M., & Ali, M. A. (2011b). Molecular authentication of the medicinal herb Ruta graveolens (Rutaceae) and an adulterant using nuclear and chloroplast DNA markers. *Genet Mol Res*, *10*(4), 2806-2816.
23. Al-Qurainy, F., Nadeem, M., Khan, S., Alansi, S., Tarroum, M., Al-Ameri, A. A., ... & Alshameri, A. (2018). Rapid plant regeneration, validation of genetic integrity by ISSR markers and conservation of Reseda pentagyna an endemic plant growing in Saudi Arabia. *Saudi journal of biological sciences*, *25*(1), 111-116.
24. Al-Rawashdeh, I. M. (2011). Genetic variability in a medicinal plant Artemisia judaica using random amplified polymorphic DNA (RAPD) markers. *International Journal of Agriculture and Biology*, *13*(2):279–282.

25. Al-Robai, S. A., Mohamed, H. A., Howladar, S. M., & Ahmed, A. A. (2017). Vegetation structure and species diversity of Wadi Turbah Zahran, Albaha area, southwestern Saudi Arabia. *Annals of Agricultural Sciences*, *62*(1), 61-69.
26. Al-Rowaily, S. L. (1999). Rangeland of Saudi Arabia and the" Tragedy of Commons". *Rangelands Archives*, *21*(3), 27-29.
27. Al-Rowaily, S. L. (2003). Present condition of rangelands of Saudi Arabia: Degradation steps and management options. *Arab Gulf Journal of Scientific Research*, *21*(3), 188-196.
28. Al-Rowaily, S. R., Assaeed, A. M., Al-Khateeb, S. A., Al-Qarawi, A. A., & Al Arifi, F. S. (2018). Vegetation and condition of arid rangeland ecosystem in Central Saudi Arabia. *Saudi Journal of biological sciences*, *25*(6), 1022-1026.
29. Alshammari, A. M., & Sharawy, S. M. (2010). Wild Plants Diversity of the Hema Faid Region (Ha'il Province, Saudi Arabia). *Asian journal of plant sciences*, *9*(8), 447.
30. Alsherif, E. A., & Fadl, M. A. (2016). Floristic study of the Al-shafa highlands in taif, western Saudi Arabia. *Flora-Morphology, Distribution, Functional Ecology of Plants*, *225*, 20-29.
31. Al-Soqeer, A. (2016). The performance of six exotic perennial grass species in the central region of Saudi Arabia. International Research Journal of Plant Science. 7(1) 012-019.
32. Al-Turki, T. A. (1997). A preliminary checklist of the flora of Qassim, Saudi Arabia. *Feddes Repertorium*, *108*(3-4), 259-280.
33. Al-Turki, T. A. (2002). 31 An Initiative in Exploration and Management of Plant Genetic Diversity in Saudi Arabia. 339-349.
34. Al-Turki, T. A., & Al-Olayan, H. A. (2003). Contribution to the flora of Saudi Arabia: Hail region. *Saudi journal of biological sciences*, *10*, 190-222.
35. Al-Yemeni, M. N., & Zayed, K. M. (1999). Ecology of some plant communities along Riyadh Al-Thumamah road, Saudi Arabia. *Saudi Journal of Biological Sciences*, *6*(1), 9-26.
36. Al-Yemeni, M., & Sher, H. (2010). Biological spectrum with some other ecological attributes of the flora and vegetation of the Asir Mountain of South West, Saudi Arabia. *African Journal of Biotechnology*, *9*(34): 5550-5559.
37. Aukema, J. E., Pricope, N. G., Husak, G. J., & Lopez-Carr, D. (2017). Biodiversity areas under threat: overlap of climate change and population pressures on the world's biodiversity priorities. *PloS one*, *12*(1), e0170615.
38. Badr, A., El-Shazly, H. H., Helail, N. S., & El Ghanim, W. (2012). Genetic diversity of Artemisia populations in central and north Saudi Arabia based on morphological variation and RAPD polymorphism. *Plant systematics and evolution*, *298*(5), 871-886.
39. Baig, M. B., Straquadine, G. S., & Aldosari, F. O. (2017). Revisiting extension systems in Saudi Arabia: emerging reasons and realities. *Journal of Experimental Biology and Agricultural Sciences*, *5*, S160-S164.
40. Bakhashwain, A. A. (2010). Fodder Yield and Quality of Rhodes Grass Alfalfa Mixtures as Affected by Sowing Rates in Makkah Region. *Journal of King Abdulaziz University: Metrology, Environment and Arid Land Agricultural Sciences*, *142*(574), 1-29.
41. Barney, J. N., & DiTommaso, A. (2003). The biology of Canadian weeds. 118. Artemisia vulgaris L. *Canadian journal of plant science*, *83*(1), 205-215.
42. Barth, H. J. (1999). Desertification in the eastern province of Saudi Arabia. *Journal of Arid Environments*, *43*(4), 399-410.
43. Batanouny, K. H., & Baeshin, N. A. (1983). Plant communities along the Medina-Badr road across the Hejaz mountains, Saudi Arabia. *Vegetatio*, *53*(1), 33-43.
44. Batanouny, K. H., & Ezzat, N. H. (1971). Eco-physiological studies on desert plants. I. Autecology of Egyptian Zygophyllum species. *Oecologia*, 170-183.
45. Boulila, A., Béjaoui, A., Messaoud, C., & Boussaid, M. (2010). Genetic diversity and population structure of Teucrium polium (Lamiaceae) in Tunisia. *Biochemical genetics*, *48*(1-2), 57-70.
46. Chaudhary SA (1999). Flora of the Kingdom of Saudi Arabia, (Vol. 1). Ministry of Agriculture and Water, Riyadh, Saudi Arabia.
47. Chaudhary SA (2000). Flora of the Kingdom of Saudi Arabia, (Vol. 2). Ministry of Agriculture & Water, Riyadh, Saudi Arabia.
48. Chaudhary SA (2001). Flora of the Kingdom of Saudi Arabia, (Vol. 3). Ministry of Agriculture & Water, Riyadh, Saudi Arabia.
49. Chaudhary SA, Al-Jowaid AA (1999). Vegetation of the Kingdom of Saudi Arabia. Ministry of Agriculture & Water, Riyadh, Saudi Arabia.
50. Chen, K., Fessehaie, A., & Arora, R. (2012). Dehydrin metabolism is altered during seed osmopriming and subsequent germination under chilling and desiccation in Spinacia oleracea L. cv. Bloomsdale: possible role in stress tolerance. *Plant science*, *183*, 27-36.
51. Chen, S., Yao, H., Han, J., Liu, C., Song, J., Shi, L., ... & Luo, K. (2010). Validation of the ITS2 region as a novel DNA barcode for identifying medicinal plant species. *PloS one*, *5*(1), e8613.
52. Chograni, H., Messaoud, C., & Boussaid, M. (2008). Genetic diversity and population structure in Tunisian Lavandula stoechas L. and Lavandula multifida L.(Lamiaceae). *Biochemical Systematics and Ecology*, *36*(5-6), 349-359.

53. Chograni, H., Zaouali, Y., & Boussaid, M. (2012). Genetic diversity and chemical polymorphism of Tunisian Lavandula multifida L.(Lamiaceae) populations. *African Journal of Biotechnology*, *11*(83), 14858-14867.
54. Collenette, S. (1985). *Illustrated guide to the flowers of Saudi Arabia*. Scorpion.
55. Collenette, S. (1998). *A checklist of botanical species in Saudi Arabia*. Int. Asclepiad Soc.
56. Collenette, S. (1999). *Wildflowers of Saudi Arabia*. National Commission for Wildlife Conservation and Development (NCWCD).
57. Conant, R. T., Cerri, C. E., Osborne, B. B., & Paustian, K. (2017). Grassland management impacts on soil carbon stocks: a new synthesis. *Ecological Applications*, *27*(2), 662-668. doi:10.1002/eap.1473.
58. Country Profile: Saudi Arabia, September (2006). Library of Congress Federal research division (http://lcweb2.loc.gov/frd/cs/profiles/ Saudi_Arabia.pdf).
59. Cunningham, S. C., Mac Nally, R., Baker, P. J., Cavagnaro, T. R., Beringer, J., Thomson, J. R., & Thompson, R. M. (2015). Balancing the environmental benefits of reforestation in agricultural regions. *Perspectives in Plant Ecology, Evolution and Systematics*, *17*(4), 301-317.
60. Dogra, K. S., Sood, S. K., Dobhal, P. K., & Sharma, S. (2010). Alien plant invasion and their impact on indigenous species diversity at global scale: A review. *Journal of ecology and the natural environment*, *2*(9), 175-186.
61. El-Demerdash, M. A., Hegazy, A. K., & Zilay, A. M. (1995). Vegetation-soil relationships in Tihamah coastal plains of Jazan region, Saudi Arabia. *Journal of Arid Environments*, *30*(2), 161-174.
62. El-Ghanim, W. M., Hassan, L. M., Galal, T. M., & Badr, A. (2010). Floristic composition and vegetation analysis in Hail region north of central Saudi Arabia. *Saudi Journal of Biological Sciences*, *17*(2), 119-128.
63. Fahmy, A. G., & Hassan, L. M. (2005). Plant diversity of wadi el Ghayl, Aseer Mountains, Saudi Arabia. *Egyptian Journal of Desert Research*, *55*, 39-52.
64. Fayed A, Zayed K (1999). Vegetation along Makkah-Taif road (Saudi Arabia). Arab. Gulf J. Sci. Res. 7, 97–117.
65. Gaafar, A. R. Z., Al-Qurainy, F., & Khan, S. (2014). Assessment of genetic diversity in the endangered populations of Breonadia salicina (Rubiaceae) growing in The Kingdom of Saudi Arabia using inter-simple sequence repeat markers. *BMC genetics*, *15*(1), 109.
66. Gitzendanner, M. A., & Soltis, P. S. (2000). Patterns of genetic variation in rare and widespread plant congeners. *American Journal of Botany*, *87*(6), 783-792.
67. Given, D. R. (1994). *Principles and practice of plant conservation*. Chapman & Hall Ltd.
68. Glenn, E. P., Brown, J. J., & Blumwald, E. (1999). Salt tolerance and crop potential of halophytes. *Critical reviews in plant sciences*, *18*(2), 227-255.
69. Goyal, A. K., Pradhan, S., Basistha, B. C., & Sen, A. (2015). Micropropagation and assessment of genetic fidelity of Dendrocalamus strictus (Roxb.) nees using RAPD and ISSR markers. *3 Biotech*, *5*(4), 473-482.
70. Hammad, I., & Qari, S. H. (2010). Genetic diversity among Zygophyllum (Zygophyllaceae) populations based on RAPD analysis. *Genet. Mol. Res*, *9*(4), 2412-2420.
71. Hamrick, J. L., & Godt, M. W. (1990). Allozyme diversity in plant species. *Plant population genetics, breeding, and genetic resources.*, 43-63.
72. Hanin, M., Brini, F., Ebel, C., Toda, Y., Takeda, S., & Masmoudi, K. (2011). Plant dehydrins and stress tolerance: versatile proteins for complex mechanisms. *Plant signaling & behavior*, *6*(10), 1503-1509.
73. Hasan, S. M. Z., Shafie, M. S. B., & Shah, R. M. (2009). Analysis of random amplified polymorphic DNA (RAPD) of Artemisia capillaris (Wormwood capillary) in East Coast of Peninsular Malaysia. *World Appl. Sci. J*, *6*(7), 976-86.
74. Hasan, S. M. Z., Shafie, M. S. B., & Shah, R. M. (2009b). Genetic variability of Artemisia capillaris (Wormwood capillary) by random amplified polymorphic DNA (RAPD) in Terengganu State, Malaysia. *African Journal of Biotechnology*, *8*(9).
75. He, Y., & Liu, J. (2003). A review on recent advances in the studies of plant breeding system. *Acta Phytoecological Sinica*, *27*(2), 151-163.
76. Hebert, P. D., Cywinska, A., Ball, S. L., & Dewaard, J. R. (2003). Biological identifications through DNA barcodes. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, *270*(1512), 313-321.
77. Heneidy, S. Z., Halmy, M. W. A., & Bidak, L. M. (2017). The ethnobotanical importance and conservation value of native plants in eastern Arabian Peninsula. *Feddes Repertorium*, *128*(3-4), 105-128.
78. Henry, R. J. (Ed.). (2001). *Plant genotyping: the DNA fingerprinting of plants*. CABI.
79. Hepsibha, B. T., Premalakshmi, V., & Sekar, T. (2010). Genetic diversity in Azima tetracantha (Lam) assessed through RAPD analysis. *Indian J Sci Technol*, *3*, 170-173.
80. Jabeen, A., Guo, B., Abbasi, B. H., Shinwari, Z. K., & Mahmood, T. (2012). Phylogenetics of selected Mentha species on the basis of rps8, rps11 and rps14 chloroplast genes. *Journal of Medicinal Plants Research*, *6*(1), 30-36.
81. Kadereit, G., Borsch, T., Weising, K., & Freitag, H. (2003). Phylogeny of Amaranthaceae and Chenopodiaceae and the evolution of C4

photosynthesis. *International journal of plant sciences*, *164*(6), 959-986.
82. Karaca, M., Ince, A. G., Aydin, A., & Ay, S. T. (2013). Cross-genera transferable e-microsatellite markers for 12 genera of the Lamiaceae family. *Journal of the Science of Food and Agriculture*, *93*(8), 1869-1879.
83. Kassas, M., & Girgis, W. A. (1964). Habitat and Plant Communities in the Egyptian Desert: V. The Limestone Plateau. *Journal of Ecology*, *52*(1), 107-119.
84. KHALIK, K. A., El-Sheikh, M., & El-Aidarous, A. (2013). Floristic diversity and vegetation analysis of wadi Al-Noman, Mecca, Saudi Arabia. *Turkish Journal of Botany*, *37*(5), 894-907.
85. Khan, S., Al-Qurainy, F., & Nadeem, M. (2012). Biotechnological approaches for conservation and improvement of rare and endangered plants of Saudi Arabia. *Saudi Journal of Biological Sciences*, *19*(1), 1-11.
86. Kingery, C. E. (1972). *Report to the Government of Saudi Arabia on Proposals for Expanding and Improving the Range, Pasture and Fodder Development and Management Programme*. Food and Agriculture Organization of the United Nations, Rome, p. 26.
87. Korkmaz, M., & ÖZÇELİK, H. (2013). Soil-plant relations in the annual Gypsophila (Caryopyhllaceae) taxa of Turkey. *Turkish Journal of Botany*, *37*(1), 85-98.
88. Korner, C. (2000). Why are there global gradients in species richness? Mountains might hold the answer. *Trends Ecol Evol*, *15*, 513-514.
89. Lande, R. (1988). Genetics and demography in biological conservation. *Science*, *241*(4872), 1455-1460.
90. Leimu, R., Mutikainen, P. I. A., Koricheva, J., & Fischer, M. (2006). How general are positive relationships between plant population size, fitness and genetic variation?. *Journal of Ecology*, *94*(5), 942-952.
91. Li, Y., Qu, J. J., Yang, X. M., & An, L. Z. (2008). A report on ultra-dry storage experiment of Zygophyllum xanthoxylon seeds. *Botanical Studies*, *49*(3), 243-251.
92. Lopez-Pujol, J. O. R. D. I., Bosch, M., Simon, J., & Blanché, C. (2004). Allozyme diversity in the tetraploid endemic Thymus loscosii (Lamiaceae). *Annals of Botany*, *93*(3), 323-332.
93. Mahmoud, A., & El-Tom, M. (1985). Ecological relationships of some vegetation units in the Jeddah-Makkah region, Saudi Arabia. *Arab Gulf journal of scientific research*. 3(2): 607-622.
94. Mallón, R., Rodríguez-Oubiña, J., & González, M. L. (2010). In vitro propagation of the endangered plant Centaurea ultreiae: assessment of genetic stability by cytological studies, flow cytometry and RAPD analysis. *Plant Cell, Tissue and Organ Culture (PCTOC)*, *101*(1), 31-39.
95. Mazer, S. J., & Wolfe, L. M. (1992). Planting density influences the expression of genetic variation in seed mass in wild radish (Raphanus sativus L.: Brassicaceae). *American Journal of Botany*, *79*(10), 1185-1193.
96. Mighaid AM (1996). In: Flora of Saudi Arabia, vol. I–III. King Abdul Aziz University Press, Jeddah.
97. Moawed, M. M. (2016). Plant flora of Alaqan region, Tabuk province, Saudi Arabia, Egypt. *J. Exp. Biol*, *12*, 107-113.
98. Mossa, J. S., Al-Yahya, M. A., & Al-Meshal, I. A. (1987). Medicinal plants of Saudi Arabia, vol. 1. *Riyadh, Saudi Arabia, King Saud University Libraries*, 262-265.
99. Motawei, M. I., & Al-Ghumaiz, N. S. (2012). Genetic diversity in some introduced pasture grass cultivars revealed by inter-simple sequence repeats (ISSR) markers. *African Journal of Biotechnology*, *11*(15), 3531-3536.
100. Mseddi, K. H. A. L. I. L., Alghamdi, A., Sharawy, S. H. A. R. I. F., & Ibrahim, N. A. S. E. R. (2017). Screening of weeds and their effect on alfalfa (Medicago sativa). *Indian Journal of Agricultural Sciences*, *87*(11), 1565-71.
101. Mseddi, K., Al-Shammari, A., Sharif, H., & Chaieb, M. (2016). Plant diversity and relationships with environmental factors after rangeland exclosure in arid Tunisia. *Turkish Journal of Botany*, *40*(3), 287-297.
102. Mustafa, A. M. A., Badr, A., El-Galaly, M. A., Mobarak, A. A., & Hassan, M. G. (2006). Genetic diversity among Ocimum populations in Egypt as reflected by morphological, seed proteins and isozyme polymorphism. *Int. J. Bot*, *2*(3), 261-269.
103. Nazar, N., & Mahmood, T. (2011). Morphological and molecular characterization of selected Artemisia species from Rawalakot, Azad Jammu and Kashmir. *Acta physiologiae plantarum*, *33*(2), 625-633.
104. Negi, D., & Saxena, S. (2010). Ascertaining clonal fidelity of tissue culture raised plants of Bambusa balcooa Roxb. using inter simple sequence repeat markers. *New Forests*, *40*(1), 1-8.
105. Nybom, H. (2004). Comparison of different nuclear DNA markers for estimating intraspecific genetic diversity in plants. *Molecular ecology*, *13*(5), 1143-1155.
106. Osman, A. K. E., & Abdein, M. A. E. H. (2019a). Karyological and molecular studies between six species of Plantago in the Northern border region at Saudi Arabia. Journal of Taibah University for Science, 13(1), 297-308.
107. Osman, A. K. E., & Abdein, M. A. E. H. (2019b). Floristic diversity of Wadi Ar'ar, Saudi Arabia. *Journal of Taibah University for Science*, *13*(1), 772-789.
108. Osman, A. K., Al-Ghamdi, F., & Bawadekji, A. (2014). Floristic diversity and vegetation analysis of Wadi

Arar: A typical desert Wadi of the Northern Border region of Saudi Arabia. *Saudi journal of biological sciences*, *21*(6), 554-565.

109. Puppo, P., Curto, M., & Meimberg, H. (2016). Genetic structure of Micromeria (Lamiaceae) in Tenerife, the imprint of geological history and hybridization on within-island diversification. *Ecology and evolution*, *6*(11), 3443-3460.
110. Quézel, P. (1978). Analysis of the flora of Mediterranean and Saharan Africa. *Annals of the Missouri Botanical Garden*, 479-534.
111. Reed, D. H., & Frankham, R. (2003). Correlation between fitness and genetic diversity. *Conservation biology*, *17*(1), 230-237.
112. Rodrigues, L., van den Berg, C., Póvoa, O., & Monteiro, A. (2013). Low genetic diversity and significant structuring in the endangered Mentha cervina populations and its implications for conservation. *Biochemical systematics and ecology*, *50*, 51-61.
113. Sadder, M. T., & Al-Doss, A. A. (2014). Characterization of dehydrin AhDHN from Mediterranean saltbush (Atriplex halimus). *Turkish Journal of Biology*, *38*(4), 469-477.
114. Seddon, P. J. (2000). Trends in Saudi Arabia: increasing community involvement and a potential role for eco-tourism. *Parks*, *10*(1), 11-24.
115. Shaltout, K. H., & Mady, M. A. (1996). Analysis of raudhas vegetation in central Saudi Arabia. *Journal of Arid Environments*, *34*(4), 441-454.
116. Sharawy, S. M., & Alshammari, A. M. (2009). Checklist of poisonous plants and animals in Aja Mountain, Ha'il Region, Saudi Arabia. *Australian Journal of Basic and Applied Sciences*, *3*(3), 2217-2225.
117. Sharma, M. M., Verma, R. N., Singh, A., & Batra, A. (2014). Assessment of clonal fidelity of Tylophora indica (Burm. f.) Merrill "in vitro" plantlets by ISSR molecular markers. *SpringerPlus*, *3*(1), 400.
118. Shinwari, Z. K., Sultan, S., & Mehmood, T. (2011). Molecular and morphological characterization of selected Mentha species. *Pak. J. Bot*, *43*(3), 1433-1436.
119. Shmida, A. (1985). Biogeography of the desert flora. In: Evenari et al. (Eds.), Hot Deserts and Arid Shrub lands, A. Ecosystems of the World 12A. Elsevier Science Publishers B.V., Amsterdam, The Netherlands; 23–77.
120. Siddiqui, A. Q., & Al-Harbi, A. H. (1995). A preliminary study of the ecology of Wadi Hanifah stream with reference to animal communities. *Arab Gulf Journal of Scientific Research*, *13*(3), 695-717.
121. Sreekumar, V. B., & Renuka, C. (2006). Assessment of genetic diversity in Calamus thwaitesii BECC. (Arecaceae) using RAPD markers. *Biochemical systematics and ecology*, *34*(5), 397-405.
122. Taia, W. K., & El-Olyan, H. A. (2005). Habitat Variation and its Effect on the Morphological Characters of Three Wild Plant Species in El-Riyadh City. *Journal of Agricultural and Marine Sciences [JAMS]*, *10*(1), 1-4.
123. Thapa, N., & Maharjan, M. (2014) Invasive Alien Species: Threats and Challenges for Biodiversity Conservation A Case Study of Annapurna Conservation Area, Nepal. Proceedings of the International Conference on Invasive Alien Species Management. Sauraha, Nepal. Pp. 17.
124. Uysal, T., Ozel, E., Bozkurt, M., & Ertugrul, K. (2012). Genetic diversity in threatened populations of the endemic species Centaurea lycaonica Boiss. & Heldr.(Asteraceae). *Research Journal of Biology*, *2*(3), 110-116.
125. Vijayan, K., Saratchandra, B., & da Silva, J. A. T. (2011). Germplasm conservation in mulberry (Morus spp.). *Scientia Horticulturae*, *128*(4), 371-379.
126. Watts, D., & Al-Nafie, A. H. (2003). *Vegetation and biogeography of the sand seas of Saudi Arabia*. Kegan Paul.
127. Zaouali, Y., Chograni, H., Trimech, R., & Boussaid, M. (2012). Genetic diversity and population structure among Rosmarinus officinalis L.(Lamiaceae) varieties: var. typicus Batt. and var. troglodytorum Maire. based on multiple traits. *Industrial Crops and Products*, *38*, 166-176.