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ijirset@gmail.com

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Water Conservation and Adaptations in Desert Plants

Dr. Sanjay Kumar Acharya

Dept. Of Botany, Govt. Dungar College, Bikaner, Rajasthan, India

ABSTRACT: There are many different types of desert plants, including cacti, succulents, acacias, mesquite, creosote bush, and yucca. Each one has adapted in its own way to survive in the harsh desert environment.

Cacti are perhaps the best-known desert plants. They have thick stems that store water, and sparse leaves that minimize evaporation. Some cacti, such as the saguaro, can grow to be over 20 feet tall.

Succulents are another type of desert plant that are adapted for water conservation. They have fleshy leaves that store water, and often have a waxy coating that helps prevent evaporation. Many succulents, such as the aloe vera, are used for their medicinal properties.

Acacias are desert plants that have long roots that help them reach underground water sources. They also have small leaves that reduce evaporation. The acacia tree is the national tree of Israel.

Mesquite is a type of desert shrub that has long, deep roots that help it reach water sources far below the ground. It too has small leaves and a thick, waxy coating that helps prevent water loss. The mesquite tree is an important source of food and shelter for many animals in the desert.

Creosote bush is a type of desert shrub that is adapted to survive in very dry conditions. It has small leaves and a deep root system that helps it reach underground for water. The creosote bush is the state flower of Arizona.

Yucca is a type of desert plant that has long, sharp leaves that help it capture moisture from the air. It also has a deep root system to help reach underground for water sources. The yucca plant is an important source of food and shelter for many animals in the desert.

KEYWORDS: water conservation, desert plants, adaptations

I.INTRODUCTION

Desert ecology is the study of interactions between both biotic and abiotic components of desert environments. A desert ecosystem is defined by interactions between organisms, the climate in which they live, and any other non-living influences on the habitat. Deserts are arid regions that are generally associated with warm temperatures; however, cold deserts also exist. Deserts can be found in every continent, with the largest deserts located in Antarctica, the Arctic, Northern Africa, and the Middle East.

Deserts experience a wide range of temperatures and weather conditions, and can be classified into four types: hot, semiarid, coastal, and cold. Hot deserts experience warm temperatures year round, and low annual precipitation. Low levels of humidity in hot deserts contribute to high daytime temperatures, and extensive night time heat loss. The average annual temperature in hot deserts is approximately 20 to 25 °C, however, extreme weather conditions can lead to temperatures ranging from -18 to 49 °C.[1,2,3]

Rainfall generally occurs, followed by long periods of dryness. Semiarid deserts experience similar conditions to hot deserts, however, the maximum and minimum temperatures tend to be less extreme, and generally range from 10 to 38 °C. Coastal deserts are cooler than hot and semiarid deserts, with average summer temperatures ranging between 13 and 24 °C. They also feature higher total rainfall values. Cold deserts are similar in temperature to coastal deserts, however, they receive more annual precipitation in the form of snowfall.[1] Deserts are most notable for their dry climates; usually a result from their surrounding geography. For example, rain-blocking mountain ranges, and distance from oceans are two geographic features that contribute to desert aridity. Rain-blocking mountain ranges create Rain Shadows. As air rises and cools, its relative humidity increases and some or most moisture rains out, leaving little to no water vapor to form precipitation on the other side of the mountain range.

Deserts occupy one-fifth of the Earth's land surface and occur in two belts: between 15° and 35° latitude in both the southern and northern hemispheres.[2] These bands are associated with the high solar intensities that all areas in the

tropics receive, and with the dry air brought down by the descending arms of both the Hadley and Ferrell atmospheric circulation cells. Dry winds hold little moisture for these areas, and also tend to evaporate any water present.

Many desert ecosystems are limited by available water levels, rather than rates of radiation or temperature. Water flow in these ecosystems can be thought of as similar to energy flow; in fact, it is often useful to look at water and energy flow together when studying desert ecosystems and ecology.[3]

Water availability in deserts may also be hindered by loose sediments. Dust clouds commonly form in windy, arid climates. Scientists have previously theorised that desert dust clouds would enhance rainfall, however, some more recent studies have shown that precipitation is actually inhibited by this phenomenon by absorbing moisture from the atmosphere. This absorption of atmospheric moisture can result in a positive feedback loop, which leads to further desertification.[4,5,6]

Desert landscapes can contain a wide variety of geological features, such as oases, rock outcrops, dunes, and mountains.[5] Dunes are structures formed by wind moving sediments into mounds. Desert dunes are generally classified based on their orientation relative to wind directly. Possibly the most recognizable dune type are transverse dunes, characterized by crests transverse to the wind direction. Many dunes are considered to be active, meaning that they can travel and change over time due to the influence of the wind. However, some dunes can be anchored in place by vegetation or topography, preventing their movement.[6] Some dunes may also be referred to as sticky. These types of dunes occur when individual grains of sand become cemented together. Sticky dunes tend to be more stable, and resistant to wind reworking than loose dunes.[7] Barchan, and Seif dunes are among the most common of desert dunes. Barchan dunes are formed as winds continuously blow in the same direction, and are characterized by a crescent-shape atop the dune. Seif dunes are long and narrow, featuring a sharp crest, and are more common in the Sahara Desert.[8]

Analysis of geological features in desert environments can reveal a lot about the geologic history of the area. Through observation and identification of rock deposits, geologists are able to interpret the order of events that occurred during desert formation. For example, research conducted on the surface geology of the Namib Desert allowed geologists to interpret ancient movements of the Kuiseb River based on rock ages and features identified in the area

As mentioned before, desert plants have adapted in various ways to conserve water. Some desert plants store water in their leaves, stems, or roots. Others have thick, waxy skin that helps prevent water loss. Some desert plants have small leaves that help reduce evaporation. Others have deep taproots that help them reach the underground water sources. Cacti have thick, fleshy stems that store water, and sparse leaves that minimize evaporation. Some cacti, such as the saguaro, can store up to 1,000 gallons of water in its trunk.

Succulents have dense, broad leaves that store water, and often have a waxy coating that helps prevent evaporation. Many succulents, such as the aloe vera, can store up to 96 liters (25 gallons) of water in their leaves.[7,8,9]

Acacias have long roots that help them reach water that is buried beneath the ground. They also have small leaves that reduce evaporation. The acacia tree can store up to 120 liters (32 gallons) of water in its roots.

Mesquite has long, deep roots that help it reach water sources far below the ground. It also has small leaves and a thick, waxy coating that helps prevent water loss. The mesquite tree can store up to 200 liters (53 gallons) of water in its roots.

Creosote bush has small leaves and a deep root system that helps it reach for water that is below the surface. The creosote bush can store up to 1,000 liters (264 gallons) of water in its roots.

Yucca has long, sharp leaves that help it capture moisture from the air. It also has a deep root system that helps it reach underground water sources. The yucca plant can store up to 700 liters (185 gallons) of water in its roots.

Desert plants have adapted to the harsh conditions of their habitats by developing strategies for either fast or slow growth. Fast-growing desert plants tend to be annuals, which complete their life cycles quickly and put all of their energy into reproduction. These plants grow rapidly during the wet season and produce large quantities of seeds, which they rely on to survive the dry season. Slow-growing desert plants, on the other hand, are typically perennials that live for many years. They grow more slowly and put less energy into reproduction, but they are better able to withstand drought and other stresses.

There are pros and cons to both fast and slow growth strategies. Fast-growing plants may be more likely to succeed in environments that are unpredictable or changing, but they are also more vulnerable to drought and other stresses. Slow-growing plants are the exact opposite; they may be less likely to succeed in changing environments, but they are more resistant to drought and other stresses. Ultimately, the best strategy for a desert plant depends on the specific conditions of its habitat.

Desert plants are adapted to survive in extremely hot and dry conditions. However, climate change is causing the desert to heat up even further, making it harder for these plants to survive.[10,11,12]

The main threat to desert plants from climate change are rising temperatures. As the temperature rises, the amount of water that evaporates from the soil increases. This means that there is less water available for plants to absorb through their roots.

In addition, hotter conditions can cause plants to experience more stress and reduce their growth. In some cases, they may even die.

Climate change is also causing changes in precipitation patterns in many deserts. Less rainfall can lead to drought conditions, which can further stress desert plants and reduce their growth.

Changes in precipitation can also cause flash floods, which can damage desert plants or even wash them away completely.

All of these effects of climate change make it harder for desert plants to survive and thrive. As a result, the diversity of plant life in deserts is likely to decline as climate change continues.

Although deserts have severe climates, some plants still manage to grow. Plants that can survive in arid deserts are called xerophytes, meaning they are able to survive long dry periods. Such plants may close their stomata during the daytime and open them again at night. During the night, temperatures are much cooler, and plants will experience less water loss, and intake larger amounts of carbon dioxide for photosynthesis.

Adaptations in xerophytes include resistance to heat and water loss, increased water storage capabilities, and reduced surface area of leaves. One of the most common families of desert plants are the cacti, which are covered in sharp spines or bristles for defence against herbivory. The bristles on certain cacti also have the ability to reflect sunlight, such as those of the old man cactus. Certain xerophytes, like oleander, feature stomata that are recessed as a form of protection against hot, dry desert winds, which allows the leaves to retain water more effectively. Another unique adaptation can be found in xerophytes like ocotillo, which are "leafless during most of the year, thereby avoiding excessive water loss".[15]

There are also plants called phreatophytes which have adapted to the harsh desert conditions by developing extremely long root systems, some of which are 80 ft. long; to reach the water table which ensures a water supply to the plant.[13,14,15]

II.DISCUSSION

Desert plants (xerophytes) and plants that grow in high salinity (halophytes) possess various adaptations for water conservation

- Xerophytes will have high rates of transpiration due to the high temperatures and low humidity of desert environments
- Halophytes will lose water as the high intake of salt from the surrounding soils will draw water from plant tissue via osmosis

Xerophytes

Xerophytes are plants that can tolerate dry conditions (such as deserts) due to the presence of a number of adaptations:

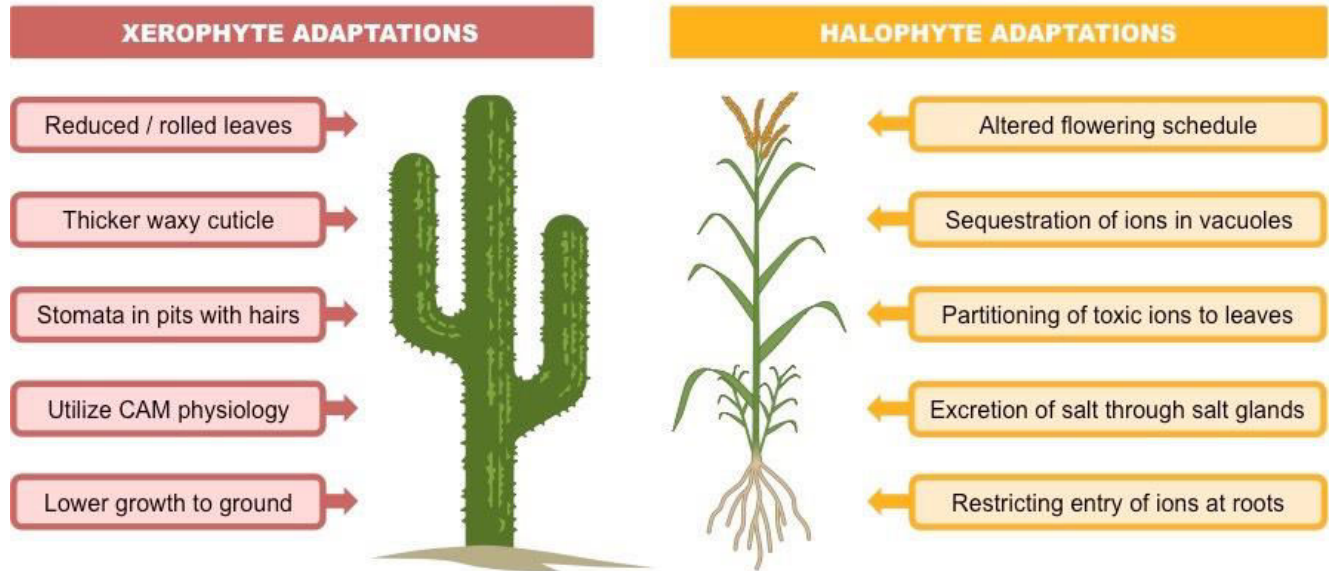
- Reduced leaves – reducing the total number and size of leaves will reduce the surface area available for water loss
- Rolled leaves – rolling up leaves reduces the exposure of stomata to the air and hence reduces evaporative water loss
- Thick, waxy cuticle – having leaves covered by a thickened cuticle prevents water loss from the leaf surface
- Stomata in pits – having stomata in pits, surrounded by hairs, traps water vapour and hence reduces transpiration
- Low growth – low growing plants are less exposed to wind and more likely to be shaded, reducing water loss
- CAM physiology – plants with CAM physiology open their stomata at night, reducing water loss via evaporation

Halophytes

Halophytes are plants that can tolerate salty conditions (such as marshlands) due to the presence of a number of adaptations:

- Cellular sequestration – halophytes can sequester toxic ions and salts within the cell wall or vacuoles
- Tissue partitioning – plants may concentrate salts in particular leaves, which then drop off (abscission)
- Root level exclusion – plant roots may be structured to exclude ~95% of the salt in soil solutions
- Salt excretion – certain parts of the plant (e.g. stem) may contain salt glands which actively eliminate salt
- Altered flowering schedule – halophytes may flower at specific times (e.g. rainy seasons) to minimise salt exposure [16,17]

Overview of Water Conservation Adaptations



III.RESULTS

In the desert water is not readily available, a lot of it is underground. Due to the lack of rain and the climate of the desert, plants have adapted to be able to retain a lot of water. This enables them to survive the harsh desert conditions. Succulents contain parenchyma cells that are specialized as water storage tissues (Sajeva and Mauseth, 1991). In a way, these parenchyma cells act as a water reservoir for succulent plants. Succulents also contain mucilage cells which are thick and gluey and they aid in water retention. They provide a slimy texture to the leaves when cut. All of this allows succulent leaves not only to absorb water but also retain water. A succulent to focus on is the Aloe vera plant as they are able to retain water in their leaves amidst the harsh weather climate. Aloe vera has a very thick epidermis that is important for water retention as it prevents excessive transpiration. On the inside you have vascular bundles that consist of tubular structures that are very important for stems and other structures. Stems play an important role in not only providing structure and support for the plant but this also allows for water and nutrients to be moved through the plant.

Another example would be the cactus genus *Opuntia*. This cactus is composed of fleshy stems called cladodes that readily grow on top of each other, which are loaded with spines found in the areoles. These cladodes readily root to form new plants frequently which makes them a very successful invasive species. They are also very salt tolerant and resistant to any damage that may be posed by animals which further helps them in protection.

Desert plants must protect themselves in order to survive and not be eaten by animals. Some defend themselves with physical defenses such as spines, while others defend themselves with toxic chemicals.

Physical Defenses

Many succulent species do not possess true branches or leaves. Instead, these sharp succulents hold highly modified branches known as areoles. These structures are where the infamous sharp spines grow from. Thus, the spines are the highly modified leaves whereas the areoles are the highly modified branches (Cacti only). Correspondingly, some cacti species appear to have hair and are extremely fuzzy. This “hair”, also called glochids, are found on the radial spines where their main function is to protect the plant from both frost and sun. The hairs we see are modified spines! However, the real question is, why would these succulents get rid of the true leaves to grow spikes? (Lita, 2021)

Succulent stems are actually able to undergo photosynthesis, and leaves aren’t needed as succulents tend to grow in areas with a lot of sunlight. Second, succulent spines reduce water loss. The spines do this by breaking up air flow, reducing evaporation, and creating a buffer zone with moist air created due to the trapped air around the cactus. Third, spines are able to collect dew in moist or foggy morning situations. The dew will then be dropped by the spines which allows the roots to absorb the water. This is done via the “special grooves” that aid the spines in collecting a significant amount of water. Fun fact: There is current research being done to replicate these specialized grooves for improved

water collection in arid climates. Lastly, spines protect the plant from predators who love tearing the cacti apart and sucking on the tissues that aid in water storage. (Fratt, 2019)[17,18]

Besides physical defense mechanisms, plants also have a secondary line of defense that falls under chemical defense protection. Physical defense mechanisms include structures such as spines whereas chemical defense includes latex. There are two families that are primarily focused on for their defensive chemical components which include Family Apocynaceae and Euphorbiaceae.

The African Milk Tree (*Euphorbia trigona*, Euphorbiaceae). We made stained slides of a cross section of a shoot. The dark purple structures are the latex-producing laticifers. When cut or squeezed, toxic latex will come out of these structures. They grow in tropical dry forests and deciduous forests.

IV.CONCLUSION

The desert biome functions in water conservation through adaptations and unique ecological processes.

Deserts are known for their extreme aridity, with some receiving less than 25mm of rainfall per year. Despite this, desert biomes are able to conserve water through various adaptations and ecological processes. One such adaptation is the ability of desert plants to store water in their tissues, allowing them to survive long periods of drought. Additionally, many desert plants have evolved to have small leaves or no leaves at all, reducing water loss through transpiration.

Another important aspect of water conservation in the desert biome is the role of soil and microorganisms. Desert soils are often shallow and rocky, which allows for rapid infiltration of water during rare rainfall events. Microorganisms in the soil also play a crucial role in conserving water, as they break down organic matter and release nutrients that help plants survive in the harsh desert environment.

Finally, desert animals have also adapted to conserve water. Many species have developed efficient kidneys that allow them to excrete concentrated urine, reducing water loss. Some animals, such as the kangaroo rat, are also able to obtain all the water they need from their food, eliminating the need for drinking water altogether.

Overall, the desert biome has evolved a variety of adaptations and ecological processes that allow for efficient water conservation in an environment where water is scarce.[18]

REFERENCES

1. Pullen, Stephanie. "The Desert Biome". University of California Museum of Paleontology. Retrieved 7 November 2017.
2. ^ "World Deserts". Mojave National Preserve: Desert Ecology. National Park Service. Retrieved 2008-02-22.
3. ^ Noy-Meir, Imanuel (1973-11-01). "Desert Ecosystems: Environment and Producers". *Annual Review of Ecology and Systematics*. 4 (1): 25–51. doi:10.1146/annurev.es.04.110173.000325. ISSN 0066-4162.
4. ^ Rosenfeld, Daniel; Rudich, Yinon; Lahav, Ronen (22 May 2001). "Desert dust suppressing precipitation: A possible desertification feedback loop". *Proceedings of the National Academy of Sciences of the United States of America*. 98 (11): 5975–5980. Bibcode:2001PNAS...98.5975R. doi:10.1073/pnas.101122798. PMC 33408. PMID 11353821.
5. ^ "Desert Features". U.S. Geological Survey. Retrieved 7 November 2017.
6. ^ Edgell, H. Stewart (2006). *Arabian Deserts*. Springer. pp. 201–238. ISBN 978-1-4020-3970-6.
7. ^ Hesse, Paul (15 November 2011). "Sticky dunes in a wet desert: Formation, stabilisation and modification of the Australian desert dunefields". *Geomorphology*. 134 (3–4): 309–325. Bibcode:2011Geomo.134..309H. doi:10.1016/j.geomorph.2011.07.008.
8. ^ "What is a Desert Landform: Features and Main Landforms in a Desert". *Earth Eclipse*. 2017-05-31. Retrieved 2019-02-17.
9. ^ Eckardt, Frank D.; Livingstone, Ian; Seely, Mary; Von Holdt, Johanna (17 October 2013). "The Surface Geology and Geomorphology Around Gobabeb, Namib Desert, Namibia". *Geografiska Annaler*. 95 (4): 271–284. doi:10.1111/geoa.12028. S2CID 128387707.
10. ^ "Desert Ecosystem". *digital-desert.com*. Retrieved 2017-05-03.



11. ^ Whitford, Walter G. (2002). Ecology of Desert Systems. San Diego, California: Elsevier Science Ltd. pp. 128, 132. ISBN 978-0127472614.
12. ^ Cloudsley-Thompson, J.L. (1996). "Current trends in desert ecology". Science Progress. 79 (3): 215–232. JSTOR 43423916.
13. ^ Buckley, Lauren (January 23, 2012). "Broad-scale ecological implications of ectothermy and endothermy in changing environments". Global Ecology and Biogeography. 21 (9): 873–885. doi:10.1111/j.1466-8238.2011.00737.x.
14. ^ Pough, F. Harvey; Janis, Christine M.; Heiser, John B. (2013). Vertebrate Life (9th ed.). Pearson. pp. 549–556. ISBN 978-0-321-77336-4.
15. ^ Reece, Jane B.; Urry, Lisa A.; Cain, Michael L.; Wasserman, Steven A. (2012). Campbell Biology Canadian Edition. Pearson. p. 835. ISBN 978-0-321-77830-7.
16. ^ "Desert Plant Survival - DesertUSA". www.desertusa.com. Retrieved 2019-05-01.
17. ^ Wettergreen, David; Bapna, Deepak; Maimone, Mark; Thomas, Geb (28 February 1999). "Developing Nomad for robotic exploration of the Atacama Desert". Robotics and Autonomous Systems. 26 (2–3): 127–148. CiteSeerX 10.1.1.92.7152. doi:10.1016/S0921-8890(99)80002-5.
18. ^ "Scientists Study Desert Air to Understand Weather and Climate". NASA Jet Propulsion Laboratory (JPL). Retrieved 2022-03-09.



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