SEASONAL DIFFERENCES AND ITS IMPACT ON WATER RELATIONS IN XEROPHYTES

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ABSTRACT

Water relations of some xerophytes have been studied in both summer and winter seasons and in three areas in Riyadh; Ancient Diriyah, Janadriah and Muzahmiah. The results showed that transmittance in plants are higher during summer than in winter. Most of plants recorded the highest degree of water content and succulence in winter, except in some plants such as, *Capparis spinosa*, *Cassia italica*, *Rhazya stricta* where the blossoming season was in summer period. The lack of saturation values recorded an increase in summer than in winter, where *Zygophyllum migahidii* recorded lower values in terms of lack of saturation since it is a sappy plant, while *Zilla spinosa* recorded the highest values in terms of lack of saturation. There was a discrepancy in osmosis of cellular juice in various plants; some of which recorded higher value in summer while the others recorded the highest value in winter. With regard to all plants, the difference, in both summer and winter, did not exceed -3 bars.

Keywords: Transmittance, Water content, shortage in water saturation, Degree succulence, Measurement osmotic .

INTRODUCTION

Water has a paramount importance as for plants and all other organisms. It is the main component of living matter in cells (protoplasm). Water also represents a percentage ranging from 70% to 90% in the fresh weight of plants (Migahid et al., 1987). Therefore, the existence survival of plants are determined by the availability of water, which is the greatest solvent for foodstuff in soil. The nutrients are to be transmitted to the plants in a dissolved substance in water, as all chemical processes and vital functions could not be performed in the absence of water. Further, water protects the plants exposed to the sun from the increase of its internal tissue temperature, because it absorbs the excess heat from plants' tissues, as well as heat resulted from

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various chemical processes that occur within it. Transmittance works to regulate the temperature of the plant (Levitt, 1972). Further, plants loss very large amounts of water from its tissues in a shape of steam in such process and the most dangerous thing that plant may experience is the lack of absorption with the increase of transmittance leading to a disorder in its water balance (Dorobantu and Vijiala, 1977).

The study attempts to find the mechanisms of various environmental compatibilities for some plants as to adapt to the very dry desert environment in Riyadh region across summer and winter, since these plants are exposing a severe differences in climatic factors, especially the temperature between summer and winter, as well as the variance in humidity and rainfall, in low moisture content of soil and in soils with abundant salinity. In order to reach a wider understanding and to provide an integrated image about the extent of endurance of such natural and wild plants to grow in severe drought conditions, this will contribute to the understanding and recognizing of the natural life of a part of the Kingdom and to make the best efforts to improve and maintain such part.

It has been noted that the intensity of transmittance per plant varies from season to another depending upon the climatic conditions, i.e. rain, moisture and temperature (Abo-Sitta and Al-Taisan, 1995). Many researchers (Slatyer, 1970; Turner and Begg, 1978; Turner and Kramer, 1980) have also noted that the decrease in transmittance is due to soil water stress. El- Monayeri et al., (1981) have also stated that the daytime transmittance rate decreases significantly with an increase in soil moisture stress and aging in four types of pennisetum (*Panicum*).

The shortage of water saturation is positively correlated to the lack of soil moisture. The decrease in soil moisture leads to a continuous shortage of water in the leaves of plants(Levitt, 1972).

Rajagopal et al., 1977 have observed, during their study of the daytime changes of the relative water content in wheat stressful and non-stressful plants, that the relative water content in stressful plants is lower than in those found in non-stressful plants during the twenty four hours. Balasimha (1987) has also recorded that the relative water content of cocoa leaves, dependent naturally on rain, is lower than relative water content found in irrigated cocoa leaves. He has also explained that cocoa plants have the ability to withstand drought. Further, it has the ability to regulate the movement of stomas which reduce the water loss by transmittance.

Emad El-Deen (1990) has recorded a higher shortage of water content in the desert plants exposed to the sun comparing to plants exposed to shade because plants exposed to shade are to be subject to stress. Moreover, Abo- Sitta (1981) has recorded different levels of water content in xerophytes either throughout the day or during the seasonal changes. Xerophytes are characterized by the compensation of stress derived from the soil by maintaining a positive

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saturation when water shortage increases. Osmotic adjustment could be defined as an increase in the active dissolved molecules in cells by an osmotic way in response to drought. Hsiao et al., 1976; Kikuta and Richter, 1988 have also stated that the plants ability to withstand high water shortage for a long time is an important feature in the economics of water of plants and demonstrates the ability of plants to withstand drought for a long time. Osmond et al. (1980) have also noted that the basic way to withstand low water stress by plants is the "osmotic adjustment". Further, Walter (1963) has explained that the plants can absorb water from the soil only if it its osmotic pressure is higher than the osmotic pressure of soil solution in which it grow. Some researchers, such as (Walter, 1955a; Kreeb, 1963; Walter and Kreeb, 1970) have pointed out that the osmotic value of cellular fluid indicates the aquatic status of plants; therefore, it is an indicator of the water balance, as well as the economics of water within plants as a whole.

Many researchers such as (Slatyr, 1961; Jarvis and Jarvis, 1963; Migahid et al., 1972; Abo-Sitta and Al- Taisan, 1995) have found that the increase in drought or salinity increases the osmotic pressure.

MATERIAL AND METHODS

The study of water relations have been conducted in field conditions over the plants subject matter of this study in summer (August) and winter (December) at intervals divided on every two hours. It started as from 08:00am till 06:00pm and included the determination of the rate of transmittance, water content, shortage in water saturation, degree succulence and the measurement osmotic stress. Five repetitions of each plant have also been conducted in each time, further, the following water relations have been measured in each time:

1. Measurement of Transmittance

The method used to measure the intensity of transmittance has relied on the speed of the weight of the cut off part. It was used by many scholars, including: (Migahid, 1948; Parker, 1957; Abd El - Rhaman and Batanouny, 1965; Migahid et al., 1972; Abo - Sitta, 1981). Results were calculated on the basis of the succulent weight. The rate of transmittance was calculated on the basis of milligram per gram per hour (mg/g.h).

2. Measurement of Water Content in Plant Tissues

Certain weight of leaves and branches of succulent plants subject matter of this study were taken and dried by placing them in the drying oven at a temperature of 85 °C for a period of 6-8 hours until its weight has been stabilized and its water content has been calculated on the basis of the succulent weight as a percentage using the following equation:

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$$RWC\ (\%) = \frac{\text{fresh weight - dry weight}}{\text{fresh weight}} \times 100$$

3. Measurement of Water Saturation Shortage

Disci / plates/ tablets and cut off parts of the transmitting plants have been utilized in estimating the shortage of saturation (green leaves & stems) similar to way adopted by Catsky (1963).

4. Measurement of Succulence Degree

The degree of Succulence is calculated by finding the ratio between the wet weight (succulent) and the dry weight under the same way followed by Dehan and Tal (1978).

5. Measurement of Osmotic Stress

Osmotic stress has been conducted over all plants under this study, where plants have been cut and placed in refrigeration at 20 °C below zero degree, then the cellular juice has been extracted and stored at a temperature of 20°C below zero degree. Thereafter, the osmotic stress has been determined using an osmosis device (V.P.O wescore 2400). This method has been used by (Fahmy, 1986; Alkhazan, 1993).

6.Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 11.0 computer software package (Forthofer and Lee 1995). The cut-off point for statistical significance was p value < 0.05, and all tests were two sided.

RESULTS AND DISCUSSION

It is indicated under (Table 1) that the average of seasonal transmittance has recorded the highest rates in most plants under this study in summer except *Rhanterium epapposum* which recorded a low rate in summer of 356 mg/g/h compared to winter of 710.33 mg/g/h. This is due to the plant dries and its leaves fall in summer but maintain the dry branches only, while in winter, the growing and blossoming season, this plant records a transmittance rate higher than those in summer. The highest average of transmittance rate has been recorded in *Zilla spinosa* of 1862.17 mg/g/h, however, the seasonal average transmittance rate was low in winter compared to the those in summer in the plants under this study with the highest rates of 990.19 mg/g/h in *Cassia italica*, while the lowest rate was recorded in *Moricandia sinaica* of 245.33 mg/g/h.

It has also found that the transmittance rate was low compared to both other remaining species; *Moricandia sinaica* and *Zygophyllum migahidii*. This is because the leaves of both plants fall in dry season, which is a morphological characteristic of some succulent plants to minimize the cuticular transmittance, Weaver and Clements (1938), Sawaf (1976) Abo-Sitta and Al-Taisan (1995).

The highest seasonal rates of water content in most plant species have been recorded in winter, where the highest once was found in *Moricandia sinaica* of 88.05%, followed by *Zygophyllum migahidii* of 85.40%, while the lowest seasonal average of water content was 70.27% in *Cassia italica* plant. In summer, *Zygophyllum migahidii* recorded a rate of 84.47%, which is the highest seasonal rate in the species under this study and lowest seasonal rate was 58.42% in *Zilla spinosa*. It was also noted that the seasonal average of water content in *Capparis spinosa*, *Rhazya stricta* and *Cassia italica* were the highest values in summer compared to winter (since it is their season of growth and blossom) (Table 1).

It was also noted that the seasonal average of water content in *Zygophyllum migahidii* was convergent in both seasons as it recorded the seasonal averages of 84.47% and 85.40% in summer and winter respectively and that is because it is succulent plant (Table 1).

The plants under this study demonstrated different levels of water content in their cells, where the increase of water quantity lost in transmittance over the quantity of water absorbed causes a water content shortage in plant because it is affected by environmental factors that is exposed to. Therefore, it exposes daily and seasonal changes, and this is what has been noted in the record of plant water content, whether during the daytime, winter and summer. This conforms to what has been found by (Abo-Sitta, 1981; Henson and Hitz, 1982). Furthermore, Alhilal (1997) stated that the water content of the soil affects the water content of plant. The results showed that there was a wider seasonal change, where it has established that the majority of species recorded the highest rate of water content in winter, except for *Capparis spinosa*, *Cassia italica* and *Rhazya stricta*. This is due to the growth season of such plants (Alnafea, 2004). As per the field inspection, with regard to *Capparis spinosa*, it is noted that leaves fall leaves in winter while the plant blossoms in April and continues in blossoming in summer. However, with regard to *Rhazya stricta* and *Cassia italic*, they blossom in summer, thus these plants are in their growth and blossoming season. This conforms to what has been stated by (Alzagt, 1990; Alzagt and Al Sheikh, 1999).

Results of the study showed that the highest seasonal rates of saturation shortage were recorded in *Zilla spinosa* by (41.04%), followed by *Heliotropium bacciferum* by (33.87%) in summer, while the lowest rate recorded during the same season was 15.33% in *Zygophyllum migahidii*. With regard to winter, the lowest seasonal rate of saturation shortage has been recorded in *Moricandia sinaica* by 11.89% while the highest rate recorded during the same season was 29.53% in *Cassia italica* (Table 1).

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Through these results, it is noted that *Zygophyllum migahidii* recorded values close to the seasonal content of saturation shortage in both summer and winter, which is low compared to other species and reached to 15.33% and 14.51%, respectively, and that's because the succulence of this plant is high; therefore the content of water is higher in summer compared to the rest of other species under this study.

It is noted that the seasonal average of saturation shortage recorded an increase in summer compared to winter in most of species under this study as a result of the intensity of transmittance, exposure to severe climatic factors and the lack of water content in the soil during this season.

The values saturation shortage from season to another has been varied due to the control of climatic factors and its change during the daytime. Vaclavik (1968) stated that the water saturation shortage is positively relative to soil moisture shortage and the decrease in soil moisture leads to continued water shortage in plant leaves. It was found that the continued shortage of saturation for a long time during the daytime means that these plants can endure a considerable quantity of such saturation shortage for a long time, which is a major and important feature in xerophytes (Batanouny et al., 1991).

The seasonal averages of succulence degree in species under this study during both summer and winter recorded the highest degree of succulence in *Moricandia sinaica* by 8.61 while recorded 7.13 in *Zygophyllum migahidii* in winter. While the highest seasonal averages recorded in summer was in *Zygophyllum migahidii* by 6.63 followed by *Capparis spinosa* which recorded 5.35 while Moricandiasinaica recorded 5.09 and the lowest rate was found in *Zilla spinosa* in summer by 2.39. In winter *Cassia italica* recorded a rate of 3.61.

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Table 1: Quarterly averages of the rates of Transmittance , Water content and the Water Saturation Shortage Plant species under study in summer and winter

Area	Species	Season	Transmittance (mg/g.h)	Water content (%)	Water Saturation Shortage (%)
Old-Dir'yah	*Datura innoxia*	August	905.67	72.72	26.76
		December	791.99	82.67	17.09
	Capparis spinosa	August	1278	80.47	19.27
		December	796.66	74.83	23.64
Jenadriah	*Rhazya stricta*	August	1059.33	76.02	23.61
		December	467.66	74.39	25.21
	Cassia italica	August	1228.17	74.82	25.04
		December	990.19	70.27	29.53
	Calotrapis procera	August	1263.99	77.58	21.94
		December	541.16	84.79	14.94
Muzahimiyah	*Moricandia sinaica*	August	548	79.22	20.72
		December	245.33	88.05	11.89
	Zygophllum migahidii	August	666	84.47	15.33
		December	588	85.40	14.51
	Zilla spinosa	August	1862.17	58.42	41.04
		December	670.49	75.21	24.09
	Heliotroph bacciferum	August	824.17	65.49	33.87
		December	438	76.57	22.99
	Rhanterium epapposum	August	356	69.17	30.71
		December	710.33	77.74	22.12

The results also indicate that the degree of succulence increases in winter and decreases in summer in the majority of species. However, with regard to *Capparis spinosa*, *Rhazya stricta* and Cassia italic, it was observed that the degree of succulence increases in summer and decreases in winter (Figure 1).

Out of water content results and succulence of these perennial xerophytes over both summer and winter, it was found that *Calotropis procera, Moricandia sinaica, and Zygophyllum migahidii* have a distinguished characteristic as they contain high levels of water content and high degrees of succulence as well, that would proves the correlation between water content and degree of succulence on the one hand; and on the other hand they represent a compatibility factor to the dry environmental conditions and this is in conformity with what has been stated by (Abd El-Rahman, 1973; Ahmed and Girgis, 1979; Marie, 1988); who explained that the degree of succulence is considered as one of the mechanisms adapted by plants as to endure adverse conditions caused by either drought or salinity.

One of the water relations of plants is that the lowest values of water content have been recorded in summer, while the lowest saturation shortage values have been recorded in winter and the highest ones in summer and this is comes in conformity with what has been found by (Altesan, 1994). The change in water content may be due to the abundance of mechanical elements and thickening walls of cells or due to the lack of water on protoplasm itself as per stated by (Alodat et al., 1985) to the effect that the plants vary in their endurance against high temperature and this is depending upon the ratio of water in their tissues; as the fewer ratio of water, the greater ability of plants to endure high temperatures, which is an adaptive attribute of xerophytes.

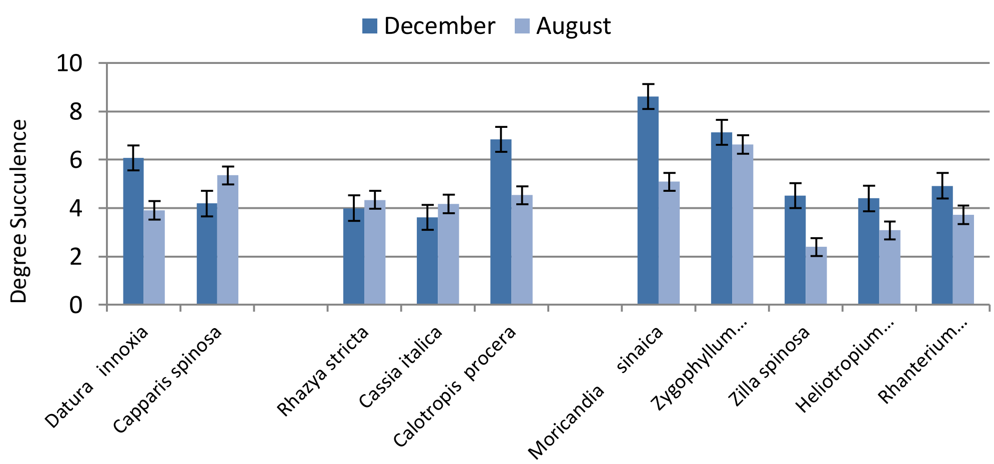

Figure 1: the quarterly average for the degree of succulent plant species studied in summer and winter

Out of the results obtained from osmotic stress, it has been observed that the majority of plants recorded higher rates in summer than in winter, where it was found that the highest rates recorded with regard to osmotic stress were -20.65 bar and -20.06 bar in both *Moricandia sinaica* and *Calotropis procera* respectively. The lowest rate was in *Caaparis spinosa* by -13.23 bars in August. While the highest rates were recorded in December by -18.47 bar in *Rhazya stricta* and the lowest one was recorded in *Heliotropium bacciferum* and *Zilla spinosa* by -12.71 bar and -12.80 bar respectively.

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By considering the values of osmotic stress in plant extracts, it was indicated that the value is lower in winter than in summer in some plants (Figure 2). This is due to the rains that reduce soil solution and salts. Therefore, roots could absorb an abundant quantity of water which would reduce the salt concentration within the cellular fluid. Many scientists (Jarvis and Jarvis, 1963; Migahid et al., 1972; Abo- Sitta and Al-Taisan, 1995) have explained that the increase in drought or salinity increases the osmotic stress accordingly.

In some other species, the highest rates of osmotic stress shortage were recorded in the winter in plants such as *Cassia italica, Rhazya stricta* and *Datura innoxia* by -18.74, -16.38 and -16.20 respectively, and this is comes in conformity with what has been stated by a Migahid et al., (1987), where the increase of ratio of solvents cellular juice may be at low temperature, especially turning starch into sugar.

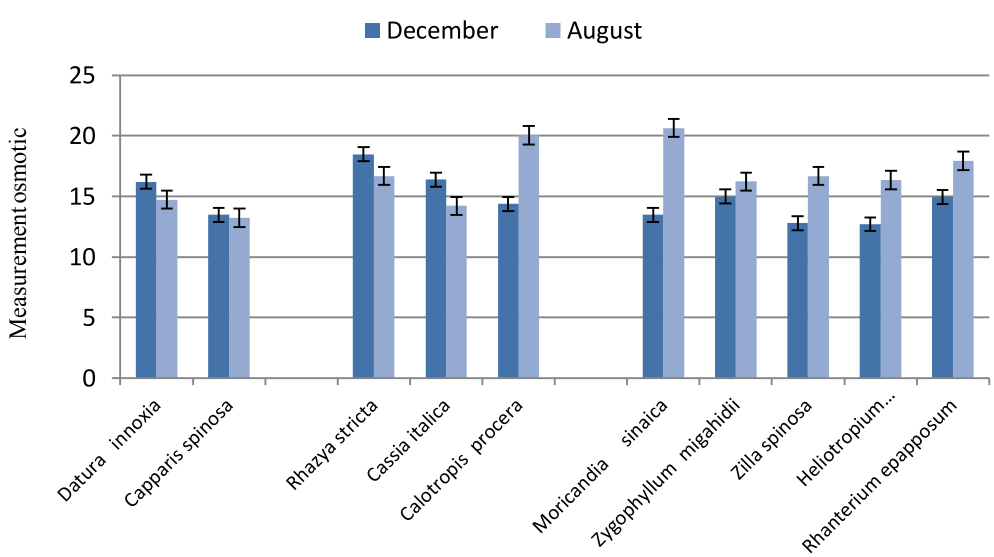

Figure 2: The average quarterly Measurement osmotic plant species studied in summer and winter

The increase of osmotic stress in juice is not entirely due to the increase of solvents in cellular juice, but it partly due to the high ratio of water trapped in the cells, which is strongly related to the protoplasm colloids and that would prevent the spread thereof in cellular juice and its participation in melting the solvents of cellular juice. Therefore, juice seems to be more concentrated than if all the free water in the cell is free to participate in melting such solvents, Migahid et al., (1990).

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Acevedo et al., (1979) have indicated that the most important compounds accumulated in *sorghum* are sugars, especially reduced sugars which would amend osmosis in the middle of the daytime as a result of the change in water stress. Alkhazan (1993) has also showed the same result in her study on sesame.

Emad El-Deen (1990) has also clarified that the desert plants growing under sun have an increased osmotic pressure in summer. Such pressure, furthermore, reaches its maximum values at the end of autumn along with the end of drought season.

CONCLUSION

This study concluded that there is a clear impact of seasonal variations on water relations of Xerophytes where they showed adaptations in water relations to enable them to survive and resist the seasonal changes. Also, Xerophytes have adopted different ways to maintain their water balance that keep their live under drought conditions and there are many mechanisms that enable these plants to grow and survive in spite of their exposure to hard environmental stresses which defined as adaptation.

It is known that all mechanisms produced by vegetation type to resist environmental stresses depending on the severity of environmental conditions surrounding this type.

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