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SEASONAL VARIATION IN LEAF RELATIVE WATER, DRY MATTER AND LIVE FINE FUEL MOISTURE CONTENTS IN SOME COMMON PLANT SPECIES OF QUETTA, BALOCHISTAN

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Abstract

An analysis was made of the seasonal variation in leaf relative water content (RWC), leaf dry matter content (LDMC), live fine fuel moisture (LFFM) in 3 woody species of Quetta, Balochistan, RWC results suggest that the stable plant species have more efficient mechanisms to reduce water losses and maintain water supply between seasons and the RWC was found with variation from season to season and plant to plant. Highest RWC was noted in *Pinus halepensis* Miller. during spring, followed by summer and autumn. LDMC was higher in the autumn season as compared to spring and summer suggesting a more efficient conservation of nutrients. The LFFM contents were also noted higher in autumn, followed by summer and spring.

Introduction

The moisture content of living-plant foliage of wild land species varies markedly with seasonal changes in growth habits except in humid climates. These changes are usually typical for the local species and climate, the decrease in plant leaf moisture is usually not smooth, but an irregular succession of ups and downs, it may even change during the course of the day. These irregularities may result from one or more causes, including periodic changes in food-manufacturing demands, changes in weather, and variations in available soil moisture. Within the individual leaf, however, moisture is maintained within tolerable limits during the growing season through the ability of the leaves to open or close the leaf pores and thereby regulate the rate of transpiration to the atmosphere. Leaf relative water content (RWC) is an indicator that is used to evaluate plant water status (Larcher, 1995; Teulat *et al* 1997). The photosynthetic rates and stomatal conductance decreased as leaf RWC decreased in plants (Penuela *et al.* 2004). Leaf dry matter content (LDMC) has also been reported as an indicator of plant resource use (Garnier et al., 2001*a*). This trait is related to leaf lifespan and it is involved in a fundamental trade-off between rapid production of biomass and an efficient conservation of nutrients (Grime et al., 1997; Poorter and Garnier, 1999; Ryser and Urbas, 2000). Garnier *et al.,* (2001*b*, reported that relative water content (RWC), live fine fuel moisture (LFFM) and leaf dry matter content (LDMC, the ratio of leaf dry mass to fresh mass) are important traits in plant ecology because they are associated with many critical aspects of plant growth and survival. Finally, living fuel moisture content, which is determined by leaf moisture (LM) and live fine fuel moisture (LFFM), is used in various fire model systems (Andrews and Beyins, 2003; Pinol et al., 2005) as a determining factor for the ignition and propagation of fire (Chandler, 1983).

The main objective of the present study was to determine the effect of seasonal changes on relative water contents (RWC), live fine fuel moisture (LFFM) and leaf dry matter contents (LDMC) in three different woody plants. Relative water contents (RWC), live fine fuel moisture (LFFM) and LDMC could be used as indicators of plant resource-use strategy in these environments. In addition, we hoped to determine different plants have different RWC, LFFM and LDMC in different seasons in the same climate.

Material and Methods

Three replicate samples from three different plants species, (*Pinus halepensis* Miller., *Eucalyptus tereticornis* L. and *Elaeagnus angustifolia* L.) were collected, during spring, summer and autumn season of the year 2011. Three Leaf variables were estimated throughout the study time: leaf relative water content (RWC), leaf dry matter content (LDMC) and in addition, live fine fuel moisture (LFFM) was also measured from leaves. Leaf samples were collected from well – grown plants and taken from the part of the canopy exposed to indirect sun light at the time of sampling. Fully, expanded leaves free from behavior or pathogen damage were served from a stem or twig, and the petioles were removed (Garnier *et al.,* 2001b). The number of leaves sampled from each individual varied according to the size and the weight and the weight of the leaves of each species. In all species, the leaves were collected between noon and 2 pm.

Relative water content (RWC): RWC was determined following an adaptation of the method used by Munne – Bosh and Pinellas (2004). Leaves were stored in ice-box conditions; inside plastic jars filled with water to saturate the leaves (a previously weighed plastic jar filled with water was used for each individual). They were stored for 6-9h, i.e. the period needed to reach water saturation (Espelta, 1996). After saturation was achieved, the fresh weight of the leaves was obtained. Plastic jars were closed hermetically and were conserved in ice box conditions so that there were no losses of water. Then the leaves were weighed outside the jar. In order to obtain their saturated weight (with a precision of 0.01g). Finally they were oven – dried for 48h at 70^{o}C and weighed. The RWC (%) was determined by the following formula;

$$\mathbf{RWC = 100x \{(Mf\text{-}Md)/ (Mt\text{-}Md)\}}$$

Where Mf is a fresh mass, Mt is a turgid mass after rehydrated the leaves, and Md is dry mass after bring the leaves in an oven. The leaf RWC takes into account the turgid mass of leaves, and so it is the proportion of the leaf water content related to the maximum water content that can potentially be achieved by the leaf. LDMC and LM were obtained with the same procedure as RWC.

Leaf dry matter content (LDMC) and Live fine fuel moisture LFFM: To determine the Leaf dry content (LDMC) and live fine fuel moisture LFFM, ten leaves from ten different individuals were collected for each species. Each leaves sample was closed in a hermetically sealed plastic bag and stored in ice box conditions so that the water lost during journeys between the field and the laboratory remained inside the plastic bag. Then they were weighed. Finally they were oven –dried for 48h at 70^{o}C and weighed again (f.wt and d.wt, with ba (precisions of 0.01g). The leaf dry content (LDMC) and Live fine fuel moisture LFFM (mg g-1) was determined as:

$$\mathbf{LDMC} = \mathit{Md/Mt}.$$

Thus LDMC is the proportion of the leaf matter content without water related to mass of the leaf with maximum water content.

$$\mathbf{LFFM = 100X\ [(Mr.\text{-}Md]}$$

These parameters indicate the water content of leaves under field conditions in relation to its dry mass

Results and Discussion

The results from each experiment are illustrated in Tables 1 to 3 and Figure 1. During spring, summer and autumn leaf relative water content (RWC) was found (86.6 - 88.8%; 65.3 - 74.8 and 50.37 - 56.35%, respectively and annual average was 69.8 - 81.8%, with *Pinus halepensis* Miller., having the highest annual percentage (81.8%) and *Elaeagnus angustifolia* L. showing least (67.6%). Seasonally highest average RWC was noted (87.6%) during spring and lowest (51.4%) during autumn (Table 1).The decrease in plant foliage moisture from spring to autumn is usually not smooth, but an irregular succession of ups and downs. These irregularities may result from one or more causes, including periodic changes in food-manufacturing demands, changes in weather, and variations in available soil moisture. Within the individual leaf, however, moisture is maintained within tolerable limits during the growing season through ability of the leaf to open or close the leaf pores and thus regulates the rate of transpiration to the atmosphere. Foliage moisture content may even change during the course of the day. Growing seasons are longest in the lower latitudes and become progressively shorter toward higher latitudes. Elevation and aspect affect local microclimate and produce local differences in seasonal development of many plant species. In mountain topography, for example, lower elevations and southern exposures favor the earliest start of the growing season. Moisture content of all new foliage is highest at the time of emergence. Similar observation was also reported by Saura-Mas and Lloret, (2007), who reported that different plant species have different RWC with great variation between season to season and species to specie. They also indicated that overall, RWC was significantly high in stable species than in seeder species. Higher water content was also observations by Paulsamy *et al.,* (2000) in *A. indica.*

Overall mean, LDMC during spring, summer and autumn was found (1.14, 1.59 and 2.13 mg g-1), respectively and annual average LDMC in all the investigated plant species was noted 1.62 mg g-1 (Table 2). Between the seasons lowest LDMC was reported during spring and highest during autumn this variation might be due to leaf age as the age increase the deposition of dry matter also increased. Similar results were also noted by Saura-Mas and Lloret (2007). They noted that there were significant differences between two seasons, the higher concentration was found in autumn as comparison to the summer season. As expected according to Garnier *et al* (2001*a*), the present results suggest that LDMC is a parameter that does not vary so much between seasons, since this parameter relies on the dry mass of the leaf and the maximum water that can be stored. Other workers also found that different species growing in the same environmental conditions have variations in their LDMC (Cunningham et al., 1999; Poorter and de Jong, 1999).

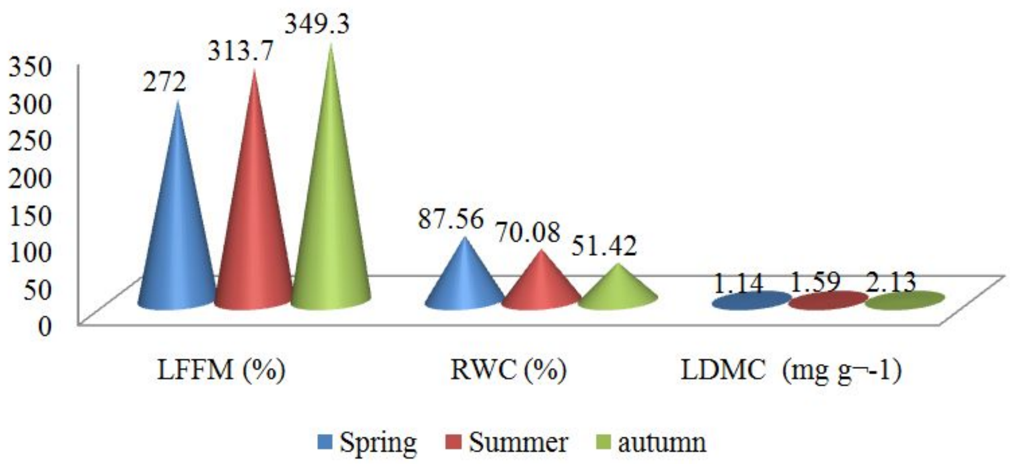

Fig. 1. Comparison between different leaf traits during different seasons.

Table 1. Average Relative Water Contents (RWC) (%) in some common plant species of Quetta Balochistan, during different seasons.

Name of Plants	Family	Spring (S.D)	Summer (S.D)	Autumn (S.D)	Annual average (S.D)
Pinus halepensis Miller.	Pinaceae	88.8 (2.0)	74.8 (3.0)	56.35 (2.5)	81.8 (9.9)
Elaeagnus angustifolia L.	Elaeagnaceae	87.3 (3.5)	65.3 (3.0)	50.37 (4.2)	67.6 (18.6)
Eucalyptus tereticornis L.	Myrtaceae	86.6 (2.2)	70.2 (2.1)	52.47 (3.0)	69.8 (17.1)
Mean		87.6 (1.1)	70.10 (4.8)	51.4 (1.5)	73.1 (7.6)

Table 2. Average Dry Matter Contents of leaf (LDMC) (mg g-1) in some common plant species of Quetta Balochistan, during different seasons.

Name of Plants	Family	Spring (S.D)	Summer (S.D)	Autumn (S.D)	Annual average (S.D)
Pinus halepensis Miller.	Pinaceae	1.23 (0.02)	1.59 (0.04)	2.41 (0.10)	1.74 (0.60)
Eucalyptus tereticornis L.	Myrtaceae	1.00 (0.10)	1.43 (0.08)	1.87 (0.09)	1.43 (0.44)
Elaeagnus angustifolia L.	Elaeagnaceae	1.20 (0.03)	1.75 (0.06)	2.12 (0.11)	1.69 (0.46)
Mean		1.14 (0.13)	1.59 (0.16)	2.13 (0.27)	1.62 (0.17)

Table 3. Average Live Fine Fuel Moisture Contents of leaf (LFFM) % in some common plant species of Quetta Balochistan, during different seasons.

Name of Plants	Family	Spring (S.D)	Summer (S.D)	Autumn (S.D)	Annual average (S.D)
Pinus halepensis Miller.	Pinaceae	312 (10.0)	356 (12.5)	387 (10.6)	351.7 (37.7)
Eucalyptus tereticornis L.	Myrtaceae	300 (12.1)	342 (14.1)	375 (12.3)	339.0 (37.6)
Elaeagnus angustifolia L.	Elaeagnaceae	204 (10.2)	243 (11.0)	286 (9.4)	345.3 (41.0)
Mean		272 (59.2)	313.7 (61.6)	349.3 (55.2)	345.3 (58.7)

The LFFM was found significantly different in different plant species and in different seasons. Overall mean contents of LFFM in all the investigated plant species during spring, summer and autumn was noted 272, 313.7 and 349.3%, respectively and annual average was 345.3%, with autumn having the highest average content of LFFM and spring showed lowest (Table 3). Similar results were found by Saura-Mas and Lloret, (2007) in their study. They indicated that LFFM were lower in spring and summer than in autumn, they also found that the different plant species differ in their LFFM contents. The comparison of investigated leaf traits indicated that there was negative correlation among RWC and LFFM and LDMC. As the RWC decrease from spring to autumn, while LDMC and LFFM increased from spring to autumn (Fig 1).

Conclusion

From this brief discussion of the weather and seasonal effects on Relative water contents, leaf dry matter contents and live fine fuel moisture, we can see that the processes involved in moisture content changes are very complex. The moisture content of a living plant is closely related to its physiology. The major variation in moisture contents, dry matter contents and live fine fuel contents are seasonal in nature, although shorter term variations are also brought about by extreme heat and drought. These moisture contents are influenced by precipitation, air moisture, air and surface temperatures, wind, and cloudiness, as well as by fuel factors such as surface to volume ratio, compactness, and arrangement.

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